GEMMOLOGISTS ASSOCIATION OF SRI LANKA
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www.gemmology.lk

Diploma in Gemmology
DGem (SL)

Practical work book

Name of the Student	
Registration No	
ATC Name	
GASL Gemmologists	
Marks	
Examiner	
Signature	
Date	

Diploma in Gemmology DGem-SL Practical Workbook Module A introduction to gemmology

Introduction

The purpose of this Diploma Practical Workbook is to train the students in identification and testing of gemstones, by providing the knowledge of gemmological instruments and also the technical training needed for the observation and testing of gemstones.

The students are expected to complete all the sections in this book in order for to obtain a complete training in attending to the Practical section of the diploma examination. The students are expected to complete all parts of the units of this book before taking up the diploma examination. Practical work book signed by GASL Gemmologist or ATC earned 10 marks in the final examination and others get 5 marks.

The students should obtain a complete knowledge in the construction and function of all the common gemmological instruments and the testing procedure of gemstones with these instruments. They should also obtain a good knowledge and experience in identification of gemstones listed in the syllabus by understanding the observable features and also in testing with common gemmological instruments.

General Procedure in Practical Training of Gemstone Testing and Identification

The following is a guide to follow an order of systematic method of training in attending to gemstone testing.

1. At the beginning is the observation

With unaided eye and under magnification, and then training with individual instruments. Thereafter, the final pages should be used for general testing of gemstones.

2. Two project report: to cover field trip or practical development of gems & gemology. Two reports should written pages of minimum 4 A4 with or without photographs of 1 1A4

Observation with unaided eye:

- Typical crystallographic features in crystals
- Characteristic features in ornamental materials
- Characteristic features in organic materials
- Special optical effect in gemstones

Observation with 10X Lens

- Typical crystallographic features in crystals
- Characteristic features in ornamental materials
- Characteristic features in organic materials

Observation by gemmological microscope

- Inclusions in cut and polished gemstones.
- Identification of gemstone species and variety.
- Distinguish natural gemstones from synthetics.
- Detecting treatments and composites

Refractometer

- Measurement of refractive indices (RI) and birefringence (DR) to 3rd decimal place
- Identification of optic character and optic sign.
- Measurement of RI by distant vision method

Polariscope and conoscope

- Crystalline character in isotropic, anisotropic and aggregate materials.
- Interference figures.

Spectroscope

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- Characteristic absorption spectra in gemstones related to the syllabus.

Dichroscope

- Dichroism in coloured mono-crystalline materials

- **Chelsea Colour Filter**

- Colour effects fluorescence in some gemstones

Ultra Violet Light

- Colour effects fluorescence in some gemstones

Specific Gravity

- S.G. measurement and weigh estimation in gems

Observation and testing of the following gemstones with all gemmological instruments as required

Inorganic Gemstones and Synthetics

- ☐ Actinolite
- ☐ Ambligonite
- ☐ Andalusite
- ☐ Apatite
- ☐ Axinite
- ☐ Benitoite
- ☐ Beryl
- ☐ Calcite
- ☐ Cassitarite
- ☐ Chrysoberyl,
- ☐ Corundum
- ☐ Cubic Zirconia
- ☐ Danburite,
- ☐ Diamond,
- ☐ Diopside
- ☐ Enstatite
- ☐ Ekanite
- ☐ Feldspar group
- ☐ Fluorite
- ☐ Garnet group
- ☐ Glass- artificial
- ☐ Glass - natural
- ☐ Gypsum (including alabaster)
- ☐ Hematite
- ☐ Idocrase
- ☐ Iolite,
- ☐ Jadeite
- ☐ Kornerupine
- ☐ Kyanite
- ☐ Lapis Lazuli
- ☐ Malachite
- ☐ Nephrite
- ☐ Opal,
- ☐ Peridot
- ☐ Phenakite
- ☐ Pyrite
- ☐ Quartz group
- ☐ Rhodochrosite
- ☐ Rhodonite
- ☐ Scapolite
- ☐ Scheelite
- ☐ Serpentine (including bowenite)
- ☐ Sillimanite
- ☐ Sinhalite
- ☐ Sodalite
- ☐ Sphene
- ☐ Spinel
- ☐ Spodumene
- ☐ Steatite (soapstone)
- ☐ Strontium Titanate
- ☐ Synthetic Moissanite
- ☐ Synthetic Rutile
- ☐ Taaffeite
- ☐ Tanzanite (Zoisite)
- ☐ Topaz
- ☐ Tourmaline
- ☐ Turquoise
- ☐ YAG
- ☐ Zircon

Organic Gems

- ☐ Amber
- ☐ Coral
- ☐ Ivory
- ☐ Jet
- ☐ Pearl
- ☐ Shell
- ☐ Tortoiseshell

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1.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

2.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

3.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

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4.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

5.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

6.	Observation and identification by unaided eye and 10x lens with	Specimen No: …………

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7.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

8.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

9.	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

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10	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

11.	Observation and identification by unaided eye and 10x lens with	Specimen No: …………

12	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

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13	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

14.	Observation and identification by unaided eye and 10x lens with	Specimen No: …………

15	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: …………

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16	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: ....

	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: ....

2)	Observation and identification by unaided eye and 10x lens with	Specimen No: ....

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3)	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: ………..

4)	Observation and identification by unaided eye and 10x lens with lamp	Specimen No: ………..

3. The Gemmological Microscope:

The main purpose of the gemmological microscope is the study of internal features in gemstones. With the advent of modern synthetics, the use of the microscope has become essential in gem testing and identification.

The Construction and Functions:

It is a special type of compound microscope which consists of a combination of low power objectives and wide field eyepieces in a binocular lens system. This provides a wide-field of vision covering a much greater area at any given magnification and a stereoscopic vision which permits objectives to locate the inclusions exactly and their nature in relation to the surrounding host mineral. This type of lens system helps also to obtain a depth of field throughout the specimen. The general magnification range in gemmological microscopes is between 40 X to 75 X, and in some it increases to around 200 X the maximum limit.

A stone holder is attached to the stage to hold and rotate the specimen in all directions for the observation of external and internal features.

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The gemmological microscope is attached with light sources to provide different types of illumination.

- **Transmitted light** - A tungsten lamp below the stage provides light to pass through the stone. This light source can be changed to provide one of the two types of background effect as required.

  - **Brightfield illumination**. The gemstone is illuminated directly by transmitted light below and the background appears light. The beam of light is made to pass through a translucent diffusion glass filter to avoid direct fall of light rays to the eyes.

    This type of illumination is useful for the observation of transparent and translucent gems, to study many types of inclusions, colour variations, growth bands, twinning planes and evidence of various kinds of treatment.

    This light is useful in testing of gemstones by the microscope in conjunction with other optical instruments, such as the spectroscope.

  - **Darkfield illumination** created by a dark disc to block direct transmission of light, provides light indirectly from a circular reflector to the gemstone. This type of lighting helps to observe the gemstone and inclusions much clearer against dark background.

    Some types of inclusions, specially light coloured ones such as fine fibres, mineral dust or minute bubbles appear more brighter against dark background.

- **Top illumination or overhead illumination** is to provide incident light for reflection from the viewing direction. Opaque and translucent gemstones and also the transparent gem materials with opaque inclusions are seen better for their colour and lustre under this method. Surface features such as polish and facet conditions are also seen better.

  Fibre optic light guide can direct light source from any direction to a precise area for better illumination.

Below the objective, with a reasonable distance is a platform, which is the stage of this microscope. It has a large central aperture to provide transmitted light from a wide area. A glass slide or immersion cell can be placed on it to keep the specimen if necessary.

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Accessories

Sub-stage accessories:

Polarizing filters, one in the body tube and the other below the stage to produce crossed polarized light. Iris diaphragm to control transmitted lighting through the adjustable circular aperture.

Immersion cell. To observe a gemstone immersed in a fluid with refractive index close to that of the stone. This makes the effect of the surface features almost invisible such as reflection of light from facets. Internal details become more clearer, such as colour concentration and growth lines. Colour concentration on facet edges in surface diffusion treated sapphires are observed under this condition.

Uses of the microscope:

a. All types of observations of as with 10 X lens, but in details when necessary.

b. Observations of inclusions, the interior features of gemstones.
   i. Under ordinary light. Transmitted light may be used either as dark field or bright field illumination, with or without overhead illumination;
      - All types of interior features in gemstones, which are collectively called inclusions.

   ii. Under plane polarized light, which is made to transmit through the gemstone.
      - Some internal features such as growth planes, twinning planes, pleochroic colours in mineral inclusions etc.
      - Pleochroism in coloured anisotropic gems. Pleochroic colours seen separately.

   iii Under crossed polarized light. (Used as the polariscope)
      - Observations as seen under the polariscope
      - Tabby extinction in some gems as in synthetic spinel, hessonite garnet etc.
      - Detect anisotropic mineral inclusions in isotropic gemstones.
      - Twinning planes, halo effect as in zircon inclusions etc.

   iv Under crossed polarizing filters with convergent light:
      - The interference figures for uniaxial and biaxial gems

c. The use of the spectroscope in conjunction with the microscope to observe the absorption spectra in gemstones.

d. Determination of approximate refractive indices by;
   - Direct measurement method through real depth and apparent depth of the gemstone
   - Becke line method.
   - The Plato method.

e. Photomicrography.

Observation of Inclusions in Gemstones.

The study of inclusions in gemstones is useful for the following;

- Identify the gems - the gem species and their varieties
- Distinguish the natural gemstones from their synthetic counterparts.

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- Distinguish natural gemstones from their imitations and identify the nature of man-made simulants such as synthetics, pastes and composites.
- Detect different forms of treatments, such as artificial colouration.
- Assess the clarity of gemstones and the likelihood of possible damage from fractures and cleavage specially for valuation.
- Understand how gemstones were formed, the nature of their environment during formation and the material from which they were formed.
- Identify the influence of inclusions specially minerals on the host gem material, the colouration, special optical effects etc. which have influenced in fashioning.
- Identify the characteristics of species and localities which will help to learn the mode of occurrence and place of origin.

For gemmological purposes the inclusions may be considered to include the following;

- Solid, liquid and gaseous materials within the gemstones.
- Planes, layers, cavities, etc. containing these materials
- Cavities of mono-phase, two phase or three phase character
- Zoning of growth, colour and other materials in distribution.
- Twinning planes
- Fractures, cleavage and stress cracks etc.
- Surface features related to internal structures.

The study of these inclusions in relation to the following behaviours will be useful;

- The colour, lustre, transparency and similar optical properties of the inclusions.
- The shape of solids, cavities containing liquid, gases etc., colour zones and growth zones.
- Pattern of concentration, distribution and orientation specially in relation to the host crystal structure.
- The possible change of state in some liquids and gases in relation to temperature changes.

The inclusions in natural gemstones have been classified into three groups according to their age relationships;

- Protogenetic inclusions which were formed before the growth of the host crystal.
- Syngenetic inclusions which were formed simultaneously with the growth of the host crystal.
- Epigenetic inclusions which were formed after the host gemstone had stopped growing.

Other observable features under microscope;

Surface features related to internal structure;

'Graining' and straight lines in gemstones such as diamond and feldspar due to twinning.
Trigons, the naturals on facets near the girdle in some diamond.
Changes in lustre on the surface of different parts of composites, cavity fillings etc..

Fractures and cleavages;

Fractures and cleavages of later formation, such as conchoidal fracture in glass or quartz, even fracture in turquoise.

Tension cracks around inclusions, V-nicks and bearding around the girdle in diamond due to cleavage.

Twinning;

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Repeated twinning, eg seen in corundum and chrysoberyl, which was considered to be a sign of natural origin is occasionally seen in synthetics grown by flame-fusion and flux melt methods.

Internal strain;

Under crossed polarized light anomalous double refractive effects can be seen more clearly in materials such as amber, diamond, almandine garnet, hessonite garnet, glass, plastics and synthetic spinel. 'Tabby extinction' in synthetic spinel and the changing effect of cross pattern in glass are clearly seen.

Doubling of back facets in double refractive gems relative to the birefringence of the gemstone.

Practical Training for Observation with Microscope

1

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

2

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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3

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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18

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19

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21

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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23

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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24

Specimen No:………	Identify the inclusions and surface features, with labelled diagrams as required

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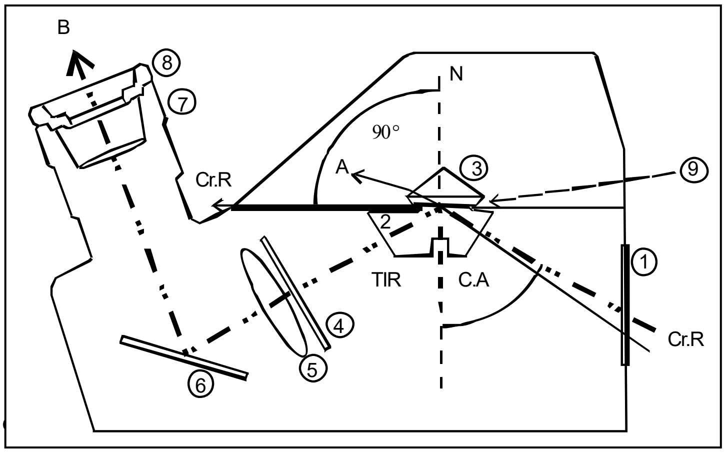
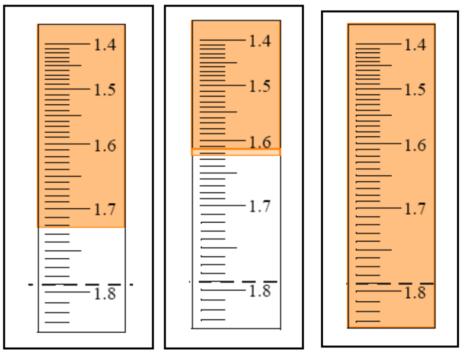
4. Refractometer

The Construction and Functions:

The function of the gemmological refractometer is based on the optical behaviour of total internal reflection of light. The measurement of the refractive index in a gemstone in by reflection of light beyond the critical angle of reflection and not by direct measurement of refraction. The optically dense medium is the optically dense glass table in the instrument and the optically rare medium is the gemstone.





Shadow edges for stones with different (1) isotropic (2) Anisotropic (3) Negative reading

1. Yellow monochromatic filter 589.3 nm
2. Dense glass table – RO 1.9
3. Gemstones on flat facet
4. Calibrated RI scale
5. Focusing lens
6. Mirror or prism for inverted scale
7. Eyepiece
8. Rotatable polarzing filter
9. High R.I. liquid. RI.1.79

A. Refracted ray
B. Total Internal Reflected ray
Cr.R. Critical Ray
C.A. Critical angle
TIR. Total Internal Reflection

The Construction of the Refractometer

Refractometer essentially consists of a high refractive dense glass, refractive index scale, eyepiece with a polarizing filter and a supply of monochromatic light.

The dense glass is the table of the instrument to keep the stone for testing, which is made from a highly refractive index material known as 'extra dense lead flint glass' and its refractive index may be high as 1.96. It is very soft and may be scratched easily, if carelessly handled. It also has a high dispersion and produces a shadow edge with a wide spectrum band of the white light.

A monochromatic light is used in order to obtain a sharper shadow edge on the scale. A narrow range of yellow light rays of wavelengths centred around 589 nm is considered to be acceptable close to 'monochromatic light' which is obtained from any of the following;

a. Sodium vapour lamp which produce yellow rays at 589 nm. (not in common use now)
b. Interference filter passing only a limited range of such rays.
c. Yellow light emitting diodes (LED)

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The scale for refractive index (R.I.) is seen through the eyepiece against which one shadow edge or two edges of total internal reflection of light for a gemstone is seen. The shadow edge divides the upper darker area in the lower RI value end of the scale from the lower bright area in the higher RI value end.

The range of the scale of RI is from 1.40 to 1.80 and graduated to two decimal places. The first digit and the first decimal values are in figures and the second decimal with short dashes. The third decimal position is to be estimated by observation.

A high RI liquid is used to exclude the air filament and make an optical contact between the glass table and the gemstone. Its refractive index is 1.79 and the highest value possible to be obtained is limited to the RI value of the liquid. A small drop is enough to be placed on the glass table and if flooded with too much liquid, correct readings could not be obtained since most of the gemstones float in this liquid. It is toxic, should avoid inhaling and prevent against eye or skin contact. It is highly corrosive and if left uncleaned, will damage the metal parts of the instrument.

Method of use:

Clean the glass table and the gemstone and place a small drop of fresh liquid on the glass table. Gently slide and position the stone, in order to keep the stones well seated and centred on the glass table. This should be done with great care to avoid any scratches or other damage on the glass table.

The eyepiece is adjusted to obtain a sharp focus on the scale. Record the reading- the position of the shadow edge - to the third decimal place in the scale, which is the refractive index (RI) for the gemstone. Rotate the polarizing filter and observe if the shadow edge is moved to another position. If so record the new position. Rotate the stone through 45° and take the reading of one shadow edge or the two shadow edges separately. Similarly take the reading from four positions at every 45° in rotation. All the reading positions should be done on any single facet, and if necessary readings can be taken on another facet similarly.

From these values the maximum and the minimum refractive indices (R.I.) and the full birefringence, ie. the greatest numerical difference between the highest and the lowest readings- also called maximum double refraction amount (D.R.)- should be obtained for gem identification. From the RI values obtained the following information are also useful in the identification of gemstones;

If the shadow edge remains single and at the same place for all the directions, the gemstone is **isotropic**. If two shadow edges seen, it is **anisotropic**.

From the **refractive indices (R.I.)** the highest reading of the high value group and the lowest reading of the low value group recorded are noted. The **birefringence** or the maximum amount of double refraction **(DR)** is the numerical difference of the highest and lowest values obtained.

The highest and the lowest values for the two groups are observed to determine the **optical character**. If one group is the same value while the value of the other group changes with the direction of the gemstones, the stone is optically **uniaxial.** If the values of both the groups are changing with the direction, the gemstone is a **biaxial** one.

The **optical sign** can be obtained by observing the relative changes in high and low values for both the uniaxial and biaxial gems.

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Uniaxial gemstones group has two indices of refraction for the two refracted rays;

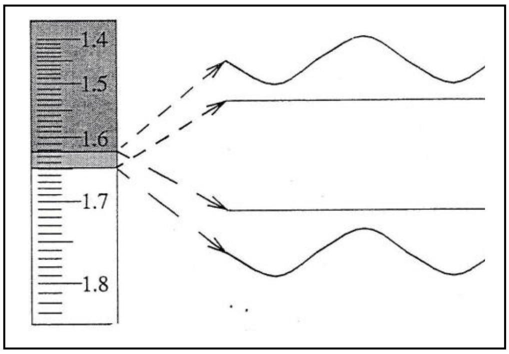
o- ray (ω) Ordinary ray - Fixed ray of constant value with the direction.
e- ray (∈) Extra-ordinary ray - Changing ray of variable values with the direction.

The optic sign - positive or negative - can be obtained from one of the following observations;

- When o-ray is less than e-ray, the optical sign is positive. When e-ray is less than o-ray , it is positive

- If the lower value is constant and the higher value varies - the gemstone is uniaxial positive. If the higher value is constant and the lower value varies - the gemstone is uniaxial negative.

- For uniaxial gemstones, normally one shadow edge moves and one is stationary. Then the sign can be decided on the following observations;



The behaviour of shadow edges in uniaxial gemstones.

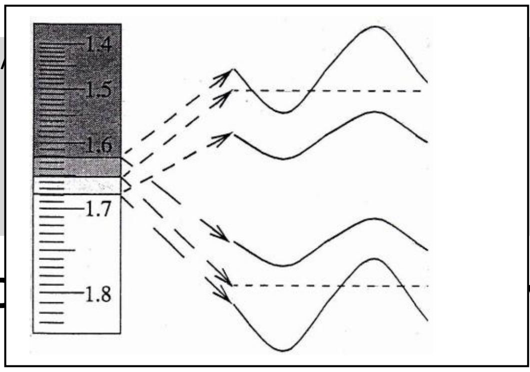
Biaxial gemstone group has three indices of refraction - the values of refracted rays for three directions of vibration

α - Least index of refraction (alpha ray) - the lowest RI value.
β - Intermediate index of refraction (beta ray) - the intermediate RI value (not midpoint).
γ - Greatest index of refraction (gamma ray) - the highest RI value.

From the refractometer readings, the values for α and γ can be directly obtained. Value for the intermediate ray is not noted for general purpose, but can be observed by obtaining the readings from two non-parallel facets. It is observed in instances when optic sign has to be decided. When the intermediate index value β is closer to the lower value α, the optic sign is positive, and when β is closer to the higher value γ, the sign is negative.

By observing the degree of change of the two rays relative to each other, optic sign can be determined. If the changes of the higher value is more than that of the lower value, the stone is optically positive. The shadow edge for the higher RI crosses the halfway between the two extreme values.

If the changes of the lower value is more than that of the higher value, the stone is optically negative. The shadow edge for the lower RI crosses half way between the two extreme values.



Shadow edge for higher RI crosses halfway point. The optic sign is positive
Shadow edge for lower RI crosses halfway point. The otic sign is negative

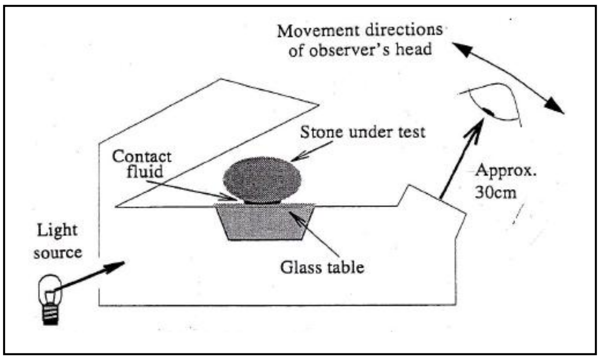
The behaviour of shadow edges in biaxial gemstones.

Distant vision technique:

Also called the spot method, and is used to test too small gemstones or those with curved surfaces, such as cabochons, which cannot be tested in the usual testing method for accurate readings. By this method only an approximate value can be obtained.

Place a small droplet of the RI liquid on the glass table and place the specimen on the liquid drop in contact with curved surface if the specimen is a cabochon or the table facet if it is a small faceted stone. Look through the eyepiece about 12 to 15 inches away from it. The liquid droplet in optical contact with the stone may be seen as a round or oval bubble. If the droplet is not seen, reposition the stone until it is seen.

With a sharp focus on the droplet, move the head in line with the refractometer, keeping the same distance from the eyepiece. As the head is moved the droplet will be seen to move in the opposite direction against the scale, appearing it light towards the higher index end and dark towards the lower index end. At one position the droplet will be seen divided equally by the shadow edge into light and dark parts. With the sight at that position move the head closer to the eyepiece to measure this position of the shadow edge on the scale. In instruments with the scale outside, the moving ribbon internally can be brought to the position and read the RI against the scale.



Set up for distant vision reading

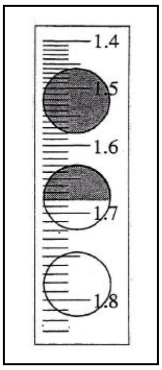


Image seen on the scale

Limitations:

Faceted gems can be tested with the instrument and cabochons shoow only an approximate value. Rough stones cannot be tested, unless a natural perfectly flat crystal face or cleavage plane may be made useful. Otherwise a polished surface should be made for observation.

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Gemstones with RI more than 1.80- more than that of the RI liquid - do not show shadow line. Such observation is called “negative reading”.

Example:

Gemstone	R.I.	Gemstone	R.I.
Demantoid Garnet	1. 875	Sphene	1. 843 - 2.110
Zircon	1.810 - 2.024	Diamond	2.417
Cubic Zirconia	2.17	Strontium Titanate	2.418
Synthetic Rutile	2. 616 - 2.903	YAG	1.832
GGG	1. 968		

False indications may be obtained in some double refractive gemstones, in which one reading falls within the refractometer scale and the other beyond the higher limit of the scale.

Gemstone	R.I.	Opt. Character	Gemstone	R.I.	Opt. Character
Rhodochrosite	1.600 - 1. 840	Uniaxial -	Azurite	1.730 - 1. 840	Uniaxial +
Benitoite	1.756 - 1. 804	Uniaxial -	Painite	1.787 - 1. 816	Uniaxial -

Some gemstones show a variation in the optic sign, for example;
Peridot and plagioclase feldspar
Values in some gemstones overlap one another and other tests are essential
Refractometer is of no use to separate natural gems from their synthetic counterparts except for synthetic spinel and some synthetic emeralds.
The prism table is very soft and may get scratched if carelessly handled. The use depends on its perfect polish.
Testing is difficult for stones with facets which are small, curved, scratched or coated.
This instrument is not useful to detect the artificial treatment in gems.

Practical Training for Testing with the Refractometer

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		
Low RI	High RI	Maximum RI………………………………………
………………	……………….	Minimum RI………………………………………
………………	……………….	DR ………………………………………
………………	……………….	Optic Character& Optic Sign …………….
………………	……………….	Conclusion …………………………………………
		…………………………………………

ATC/Gemmologist ,Stamp, Date and Signature

2

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI	
……………..	……………….	Maximum RI…………………………………….
……………..	……………….	Minimum RI…………………………………….
……………..	……………….	DR ………………………………………
……………..	……………….	Optic Character& Optic Sign …………….
		Conclusion ………………………………………
		………………………………………

3

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI	
……………..	……………….	Maximum RI…………………………………….
……………..	……………….	Minimum RI…………………………………….
……………..	……………….	DR ………………………………………
……………..	……………….	Optic Character& Optic Sign …………….
		Conclusion ………………………………………
		………………………………………

4

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI	
……………..	……………….	Maximum RI…………………………………….
……………..	……………….	Minimum RI…………………………………….
……………..	……………….	DR ………………………………………
……………..	……………….	Optic Character& Optic Sign …………….
		Conclusion ………………………………………
		………………………………………

ATC/Gemmologist ,Stamp, Date and Signature

5

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………	………………	DR ……………………………………….
……………	………………	Optic Character& Optic Sign …………….
……………	………………	Conclusion ……………………………………….
……………	………………	……………………………………….

6

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………	………………	DR ……………………………………….
……………	………………	Optic Character& Optic Sign …………….
……………	………………	Conclusion ……………………………………….
……………	………………	……………………………………….

7

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………	………………	DR ……………………………………….
……………	………………	Optic Character& Optic Sign …………….
……………	………………	Conclusion ……………………………………….
……………	………………	……………………………………….

ATC/Gemmologist ,Stamp, Date and Signature

8

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI...
Low RI	High RI	Minimum RI...
....	....	DR ....
....	....	Optic Character& Optic Sign ....
....	....	Conclusion ....
....	....	....

9

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI...
Low RI	High RI	Minimum RI...
....	....	DR ....
....	....	Optic Character& Optic Sign ....
....	....	Conclusion ....
....	....	....

10

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI...
Low RI	High RI	Minimum RI...
....	....	DR ....
....	....	Optic Character& Optic Sign ....
....	....	Conclusion ....
....	....	....

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11

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	……………….	DR ……………………………………….
……………..	……………….	Optic Character& Optic Sign …………….
……………..	……………….	Conclusion ……………………………………….
……………..	……………….	……………………………………….

12

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	……………….	DR ……………………………………….
……………..	……………….	Optic Character& Optic Sign …………….
……………..	……………….	Conclusion ……………………………………….
……………..	……………….	……………………………………….

13

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	……………….	DR ……………………………………….
……………..	……………….	Optic Character& Optic Sign …………….
……………..	……………….	Conclusion ……………………………………….
……………..	……………….	……………………………………….

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14

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
………………	……………….
………………	……………….
………………	……………….
………………	……………….

Maximum RI……………………………………….

Minimum RI……………………………………….

DR ……………………………………….

Optic Character& Optic Sign …………….

Conclusion ……………………………………….

……………………………………….

15

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
………………	……………….
………………	……………….
………………	……………….
………………	……………….

Maximum RI……………………………………….

Minimum RI……………………………………….

DR ……………………………………….

Optic Character& Optic Sign …………….

Conclusion ……………………………………….

……………………………………….

16

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
………………	……………….
………………	……………….
………………	……………….
………………	……………….

Maximum RI……………………………………….

Minimum RI……………………………………….

DR ……………………………………….

Optic Character& Optic Sign …………….

Conclusion ……………………………………….

……………………………………….

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17

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI………………………………………..
Low RI	High RI	Minimum RI………………………………………..
………………	……………….	DR ………………………………………..
………………	……………….	Optic Character& Optic Sign …………….
………………	……………….	Conclusion ………………………………………..
………………	……………….	………………………………………..

18

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI………………………………………..
Low RI	High RI	Minimum RI………………………………………..
………………	……………….	DR ………………………………………..
………………	……………….	Optic Character& Optic Sign …………….
………………	……………….	Conclusion ………………………………………..
………………	……………….	………………………………………..

19

Specimen No: …………	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI………………………………………..
Low RI	High RI	Minimum RI………………………………………..
………………	……………….	DR ………………………………………..
………………	……………….	Optic Character& Optic Sign …………….
………………	……………….	Conclusion ………………………………………..
………………	……………….	………………………………………..

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20

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
....	....
....	....
....	....
....	....

Maximum RI...
Minimum RI...
DR ....
Optic Character& Optic Sign ....
Conclusion ....
....

21

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
....	....
....	....
....	....
....	....

Maximum RI...
Minimum RI...
DR ....
Optic Character& Optic Sign ....
Conclusion ....
....

22

Specimen No:	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
....	....
....	....
....	....
....	....

Maximum RI...
Minimum RI...
DR ....
Optic Character& Optic Sign ....
Conclusion ....
....

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23

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	………………	DR ………………………………………
……………..	………………	Optic Character& Optic Sign …………….
……………..	………………	Conclusion ………………………………………
……………..	………………	………………………………………

24

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	………………	DR ………………………………………
……………..	………………	Optic Character& Optic Sign …………….
……………..	………………	Conclusion ………………………………………
……………..	………………	………………………………………

25

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
……………..	………………	DR ………………………………………
……………..	………………	Optic Character& Optic Sign …………….
……………..	………………	Conclusion ………………………………………
……………..	………………	………………………………………

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26

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
………………	………………..	DR ………………………………………..
………………	………………..	Optic Character& Optic Sign …………….
………………	………………..	Conclusion ………………………………………..
………………	………………..	………………………………………..

27

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
………………	………………..	DR ………………………………………..
………………	………………..	Optic Character& Optic Sign …………….
………………	………………..	Conclusion ………………………………………..
………………	………………..	………………………………………..

28

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement		Maximum RI…………………………………….
Low RI	High RI	Minimum RI…………………………………….
………………	………………..	DR ………………………………………..
………………	………………..	Optic Character& Optic Sign …………….
………………	………………..	Conclusion ………………………………………..
………………	………………..	………………………………………..

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29

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
………………	……………….
………………	……………….
………………	……………….
………………	……………….

Maximum RI……………………………………..

Minimum RI……………………………………..

DR ………………………………………..

Optic Character& Optic Sign …………….

Conclusion ………………………………………..

………………………………………..

30

Specimen No: ………..	Measurement of Refractive Index (RI) and Birefringence (DR)

Refractive Index Measurement

Low RI	High RI
………………	……………….
………………	……………….
………………	……………….
………………	……………….

Maximum RI……………………………………..

Minimum RI……………………………………..

DR ………………………………………..

Optic Character& Optic Sign …………….

Conclusion ………………………………………..

………………………………………..

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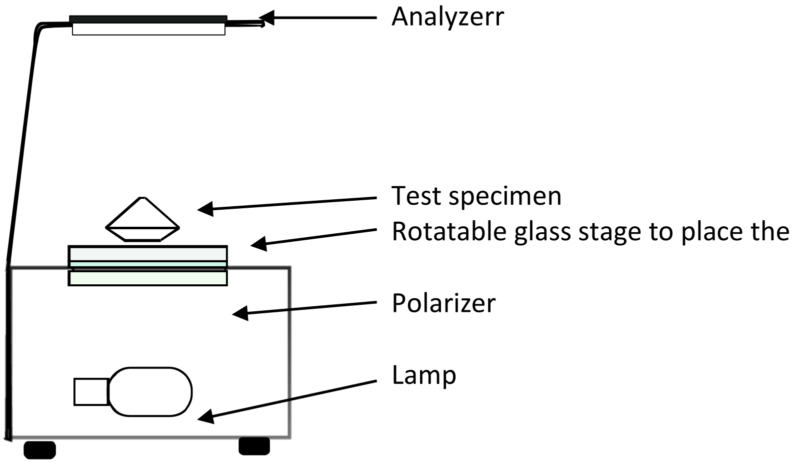
5.Polariscope and Conoscope.

The Construction and Functions of the Polariscope:

Observations	Conclusion	Related gemstone examples

The instrument consists of two polarizing filters and a light source. The two filters, one below called the polarizer and the other above called the analyzer are set in crossed position, with the polarizing directions mutually at right angles, always in testing. In this position the plane polarized light emerging from the polarizer is absorbed by the analyzer and extinction is observed.



stone

Polariscope

Method of use

Make sure that the stone is clean and has sufficient transparency for passage of light. Rotate the stone in all directions. The stone should be kept on the glass stage with the table facet and then in several other directions to obtain a clear observation. If the stone appears vaguely dark or show various colour effects in a position, it may be the direction of an optic axis in an anisotropic stone. The stone should be observed in other directions and rotated to observe a clear extinction effect. If interference colours are seen in a direction, it is the direction of optic axis, and the conoscope should be used to identify the interference figure

Observations:

a. Specimen remains dark when rotated and it is **optically isotropic**. Such materials of the following;
   - Gems of the cubic system: Spinel, fluorite and some garnets.
   - Amorphous materials: Opal, natural glass, pastes and plastics.

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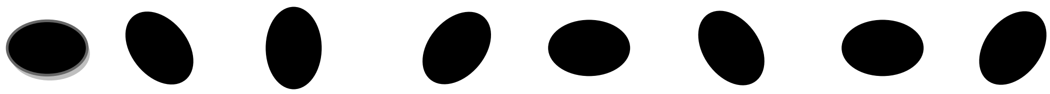
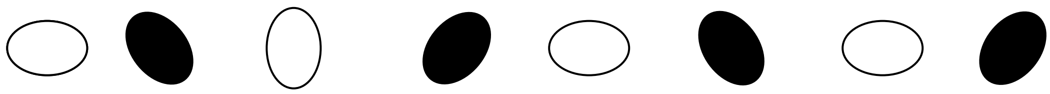
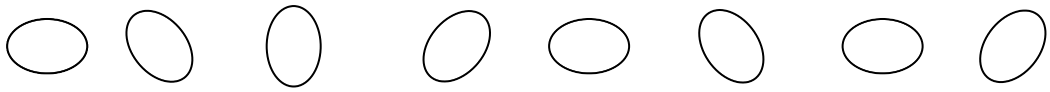
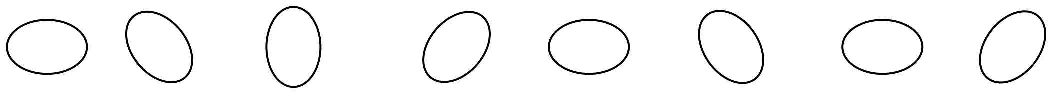
Stone remains dark in rotation	Optically isotropic- Cubic system gems or amorphous material	Some of garnets, spinels, diamonds, natural and glasses, opal & plastic
		
Stone shows dark & light , 4 times each alternately through 360°	Optically anisotropic – uniaxial or biaxial	All single crystal gemstones of the other six systems
		
Stone shows light throughout rotation	Polycrystalline gems, gems full of inclusions or twinned planes	Chalcedony, jades, Star and cat's eye varieties, twinned materials, hessonite garnet, composites, fluorites with cleavages
		
Stone shows anomalous extinction	Optically isotropic materials with internal anisotropic strain	Verneuil synthetic spinel, some glasses, almandine garnet, some diamonds, amber and plastic
		

b. Specimen becomes dark and bright alternately at every 45° in rotation. The material is optically **anisotropic**. These gems are all double refractive, both of uniaxial and biaxial in optical character, such as beryl, chrysoberyl, corundum, topaz, zircon etc.

c. The specimen remains light throughout rotation. The following materials display this effect;

- **Aggregates**, usually polycrystalline materials such as chalcedony, agates, jades etc.
- Some twinned crystals (polysynthetic twinning) such as twinning in sapphire
- Some doublets, eg. natural / synthetic corundum doublets.
- Anomalous reflection effects from cleavage as in fluorite.

d. The specimen exhibits light and dark zones, lines, bands or cross shapes which move across the test specimen during rotation. The same effect is seen in all orientations. This optical effect is called 'anomalous double refraction' or '**anomalous extinction effect'**. The

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effect is seen differently in some pastes, natural glasses and some diamonds, almandine garnet and amber, synthetic spinel by flame fusion method and hessonite garnet. The effect is better seen under optical magnification.

Other observations

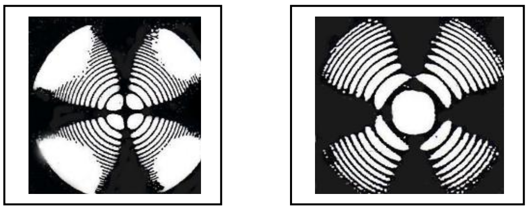
Other anomalous extinction and colour effects;

- Different extinction positions in composites (doublets and triplets) and also in twins which contain two or three parts.
- Multi-coloured stripped effect in lamellar twinning in feldspars and corundum.

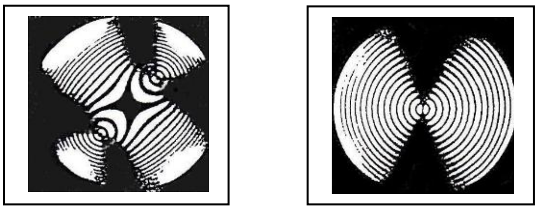
Four main types of observation

With conoscope under converging light, along the optic axis / axes following interference figures are observed;

- **Uniaxial interference figure** in uniaxial gems: A stationary dark cross with the dark centre surrounded by interference coloured rings.
  - **"Bull's Eye"** interference figure. The uniaxial interference figure, but with a bright coloured centre displayed in quartz.
- **Biaxial interference figure** in biaxial gems: Two sets of coloured rings centred around two separate positions - the two optic axes. It may appear either,
  - as a dark cross which traverses two sets of concentric coloured rings,
  - as two dark 'brushes' each traversing one set of concentric coloured rings, or
  - as concentric coloured rings traversed by one curved single 'brush'.



Uniaxial Interference Figures
Common **Bull's Eye in quartz**



Biaxial Interference figures
Two Brushes **One Brush**

Limitations in the use of polariscope:

Reflection of light within the stone may mislead to observe singly refractive gemstones as a double refractive one, since the reflected light is plane polarized to some extent.

Cabochon stones with coarsely ground base may appear light throughout rotation.

Those with many inclusions, or those with cleavage crack or fractures cannot be tested positively.

When the faceted stones are laced with the table facet downwards, light ray refract away from the direction of vision, thus making it difficult to make a decision.

Observation under Polariscope

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1

Specimen No:	Observations & Conclusion

2

Specimen No:	Observations & Conclusion

3

Specimen No:	Observations & Conclusion

4

Specimen No:	Observations & Conclusion

5

Specimen No:	Observations & Conclusion

6

Specimen No:	Observations & Conclusion

7

Specimen No:	Observations & Conclusion

8

Specimen No:	Observations & Conclusion

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9

Specimen No:	Observations & Conclusion

10

Specimen No:	Observations & Conclusion

11

Specimen No:	Observations & Conclusion

12

Specimen No:	Observations & Conclusion

13

Specimen No:	Observations & Conclusion

14

Specimen No:	Observations & Conclusion

15

Specimen No:	Observations & Conclusion

16

Specimen No:	Observations & Conclusion

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17

Specimen No:	Observations & Conclusion

18

Specimen No:	Observations & Conclusion

19

Specimen No:	Observations & Conclusion

20

Specimen No:	Observations & Conclusion

21

Specimen No:	Observations & Conclusion

22

Specimen No:	Observations & Conclusion

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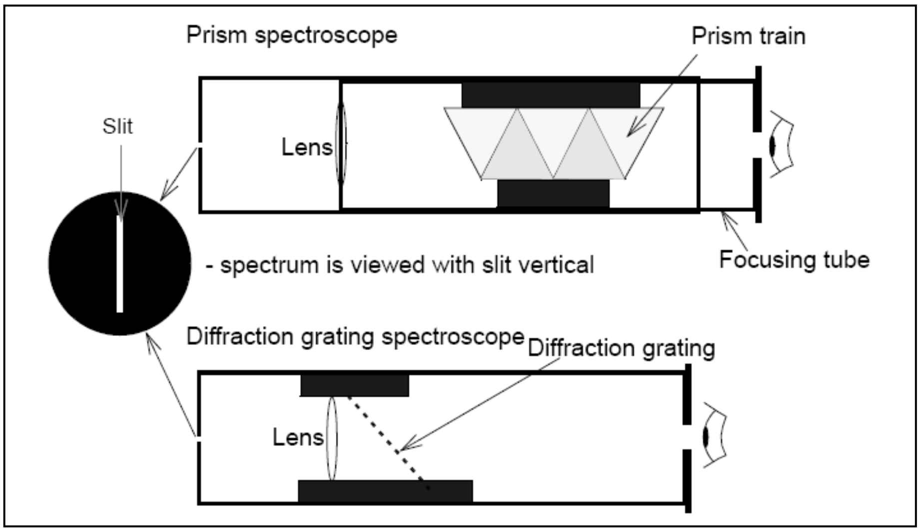
6. The Spectroscope:

The spectroscope is a simple gemmological instrument to study the absorption of coloured rays of the visible spectrum. Certain elements, which are specially responsible for the colour in gemstones cause the abortion of certain definite wavelengths of the white light and these positions are seen as gaps in the white light spectrum. The spectrum seen from the spectroscope is in fact the repetition of its narrow aperture continuously for coloured rays throughout the spectrum. The wavelengths absorbed by a gemstone are therefore seen as dark lines or bands, the pattern of which is called the absorption spectrum.



Two types of spectroscope

The Construction and Functions:

The instrument is a simple metal tube with a narrow slit at one end, and a device to produce the spectrum inside. A lens is fixed to allow the eye to focus on the image of the slit. The image of the slit is repeated into a continuous band of spectral colours. There are two types of spectroscope, each producing the spectrum differently.

a. The prism type, in which a series of prisms produces the spectrum by dispersion on refraction.

b. The diffraction type, in which fine-ruled grating produces a spectrum by diffraction.

The Construction of the Prism Spectroscope and the Diffraction Spectroscope.

The prism spectroscope produces a spectrum with a slight difference in distance of the focus. An adjustment of the focus has to be made by means of a sliding tube in examining from one end to the other end of the spectrum.

The dispersion of the colours by the prism is not linearly equal throughout the prism. The colours towards the red end are bunched more closely while the rays towards the violets end are spread out.

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The diffraction type spectroscope produces a linear spectrum. The whole spectrum is at one focal length and no focusing is necessary.

If the slit which admits light is adjustable, it is important to use the narrowest slit possible in order to study the finer lines. But a compromise is made for sharpness and brightness.

The light source, usually incident light should be strong enough to produce brightness from the gemstone, since some specimens are deeply coloured. Light source from the pen torch or the fibre optic light guide is useful, but may not produce much light in the deep violet. Some LED lights also can be used. Sunlight and fluorescent light are not suitable.
Light source can be used as internally reflected light. The gemstone should be placed with table facet down and when light is made to fall about 45° from the table, reflected rays can be picked up by the spectroscope from a similar opposite angle.

Light can be used as transmit through the gemstones for direct observation, specially when it is a rough stones or a dark coloured one. The spectroscope can be fitted to the microscope in place of the occular to observe spectra under controlled lighting.

Observations:

When the instrument is held to display a horizontal band of the spectrum with the red end to the left side and the violet end to the right side, the absorption lines are seen as vertical dark lines, the whole series of which collectively seen is called the absorption spectrum. In the study of the absorption spectrum, the positions in relation to colour regions should be observed. The relative widths of bands and lines should be examined to note whether they are lines or bands (broader areas), broad or narrow, sharp or diffused and strong or weak, whereby the characteristic pattern of absorption bands for different gem varieties can be studied. The number lines or groups may also be noted.

By observing the spectra of gemstones, the presence of some chemical elements, specially which produce colour, can be studied. These elements are transition elements, rare earth elements and radio-active elements.

Since the sunlight absorption lines or the emission lines from the overhead fluorescent lamps may be seen from the spectroscope by reflection from polished facets, care should be taken to avoid the fall of such light on the gemstone.

In addition to the absorption regions appearing as dark lines or bands, emission lines as bright lines are seen in ruby, as a bright line in the deep red and in red spinel with a series of lines in red.

Uses:

The spectroscope is a very handy instrument for quick use to observe the absorption pattern of visible wavelengths related to certain colouring elements and can be used to observe in transparent to translucent gems of any state,- rough or fashioned materials, those mounted in jewellery, carvings and other ornaments

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By observing the characteristic absorption spectra for some elements, the gemstones which contain these elements can be identified.

The test can be made on rough gem material as well as fashioned materials and it is quick method if identification of some gemstones.

Some of the treated gemstones can be distinguished from untreated ones, due to weakening of lines or emergence of new lines after treatment.

Some gemstones can be distinguished from their synthetic counterparts and also the simulants.

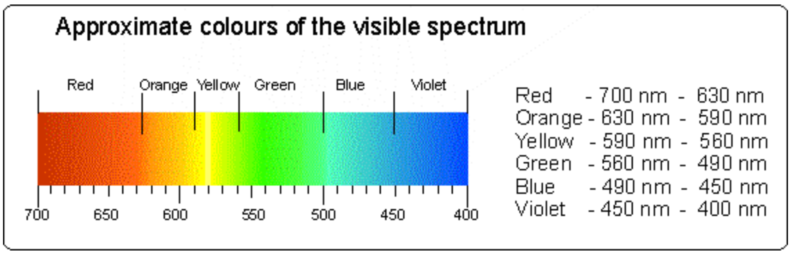
Some gemstones with RI above the higher limit of the refractometer scale can be identified.

Spectrum analysis provides one of the tests leading to the conclusive identification of many gem materials.

Colourless gemstones do not show any spectrum, except for few. Diamond, colourless zircon, pale coloured apatite and enstatite which appear almost colourless display the spectrum.

Observation of the Visible Spectrum:

The visible spectrum consists of coloured rays of definite wavelengths, and the coloured regions with the approximate wavelength ranges are the following;



Important absorption spectra in some gems are shown below as seen by the prism spectroscope as well as the diffraction grating spectroscope. These are the ideal absorption spectra for the particular gemstone, but the following variations may be noted.

a. The depth or intensity of absorption lines and bands varies with the intensity of the colour, clarity and the size of the gemstone as well as with the variation in the amount or direction of the light source.

b. Gemstones from different localities having different chemical characteristics may show variations in the details of the absorption spectrum.

c. In some isotropic gemstones, with the optical orientation some variations may be seen eg. in emerald and alexandrite.

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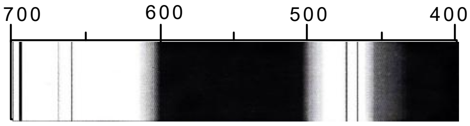
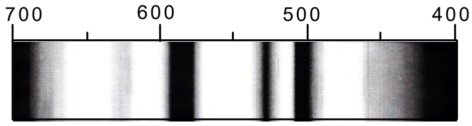
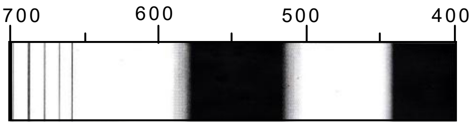


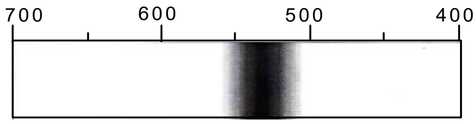
Ruby – Chromium(Cr) Spectrum
Bright line in red, also appears as dark line (doublet) Broad band in green and yellow; Absorption in violet. Fine lines in blue; Additional lines in red



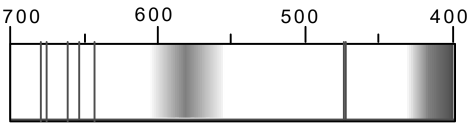
Almandine - Iron (Cr) Spectrum.
Three bands in blue-green, green and yellow. Middle band is thinner and closer to band in yellow, both appear to merge as one in dark stones



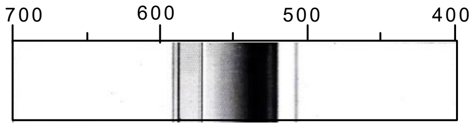
Red Spinel - Chromium (Cr) Spectrum
Several Bright lines in red; Broad band in green; Absorption in violet; No lines in blue



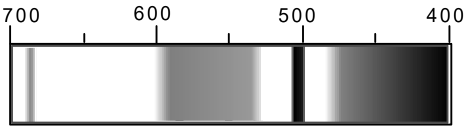
Red Glass – Colloidal gold (Au) spectrum.
One faint band in green



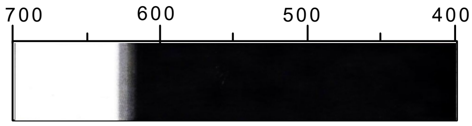
Alexandrite –Chromium (Cr) Spectrum
Two lines in red, band in orange-yellow, band in violet, line in blue, additional lines in red



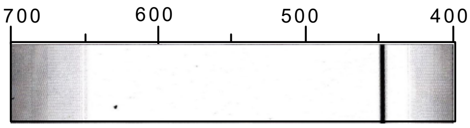
Red Glass- Rare Erath Elements (REE) Spectrum
Several sharp lines and bands in green and yellow which vary, depending on type of manufacture



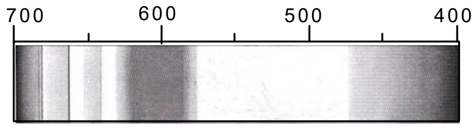
Chrome Pyrope – Chromium(Cr) Spectrum
Line in red, band in green, band in violet and line in blue-green



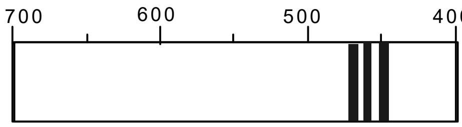
Red Glass – Selenium (Se) Spectrum
More or less complete absorption from 620nm to 400nm, except red area



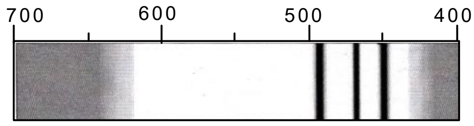
Blue Sapphire –Iron (Fe^{2+}) Spectrum
Weak line at 450nm in blue-violet boundary



Emerald- Chromium (Cr) Spectrum
Line(doublet) in red, band in orange-yellow, band in violet, additional lines in red



Sapphire; Blue, Green, Yellow- Iron (Fe^{3+})Spectrum
Three lines in blue around 450nm (450 complex)



Peridot- Iron (Fe) Spectrum
Three lines in blue between 500 and 450nm

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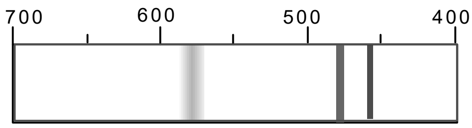
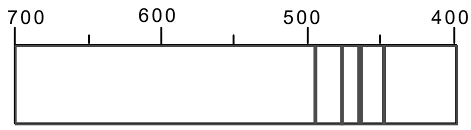
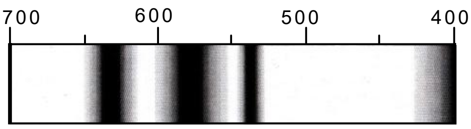


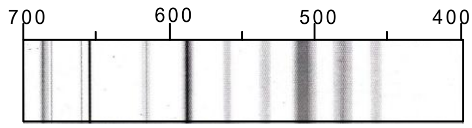
Natural Spinel – Iron (Fe) Spectrum
Lines in blue, weak band in green



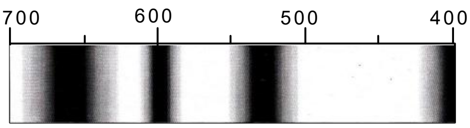
Sinhalite- Iron (Fe) Spectrum
Four lines in blue between 500 and 450 nm



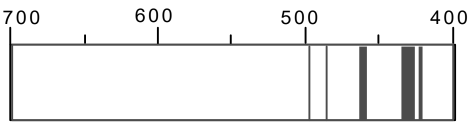
Synthetic Blue Spinel - Cobalt (Co) Spectrum
Three bands, thick, thick and thin in order in red, yellow and green areas



Zircon- Uranium (U) Spectrum
Strong line in red at 653nm. Additional lines from few to about 40 lines depending on low type to high type



Blue Glass – Cobalt (Co) Spectrum
Three thick bands- thick, thin and thickest in order in green, orange and red



Spessartine Garnet- Manganese (Mn) Spectrum
Lines in blue and green

Apatite

Enstatite

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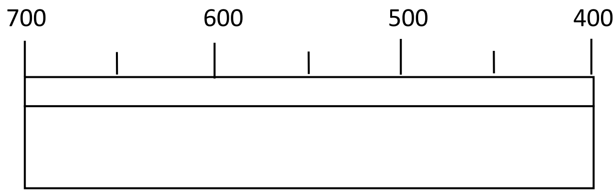
Practical traing for testing with Diffraction Grating Spectroscope

1

Specimen No: …………

Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

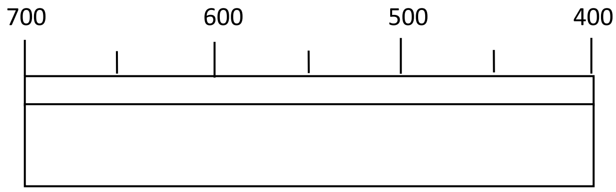


2

Specimen No: …………

Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

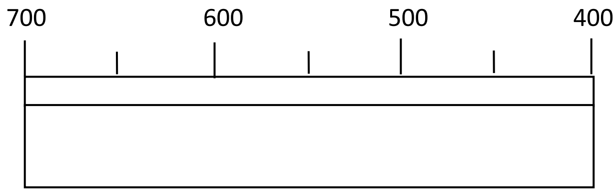


3

Specimen No: …………

Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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4

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

5

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

6

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

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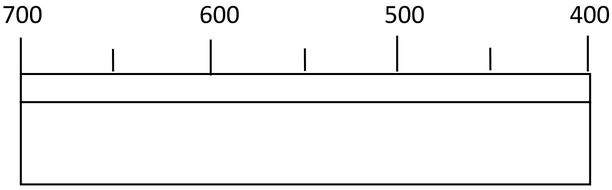
7

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

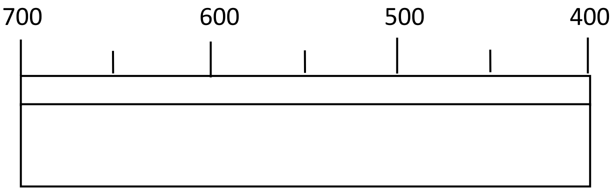
Description of the spectrum



8

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

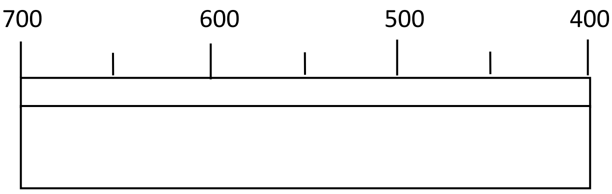
Description of the spectrum



9

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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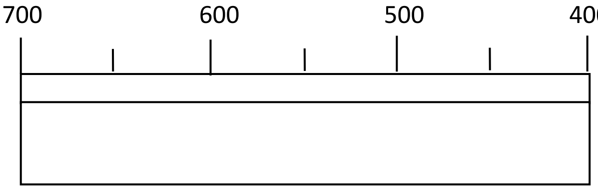
10

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

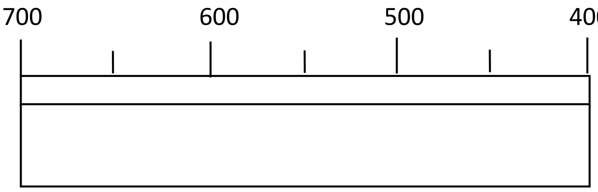
Description of the spectrum



11

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

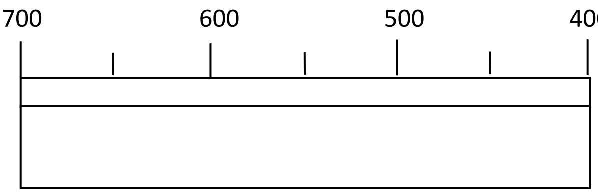
Description of the spectrum



12

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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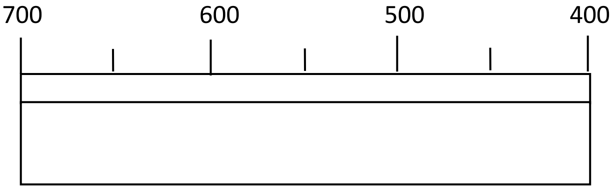
13

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

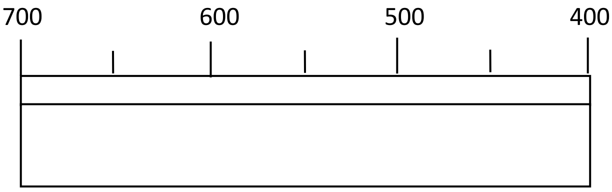
Description of the spectrum



14

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

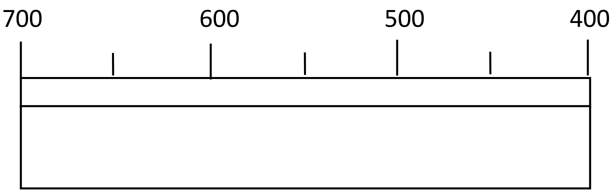
Description of the spectrum



15

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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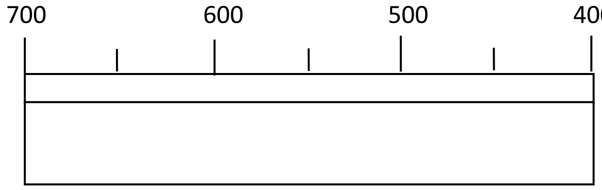
16

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

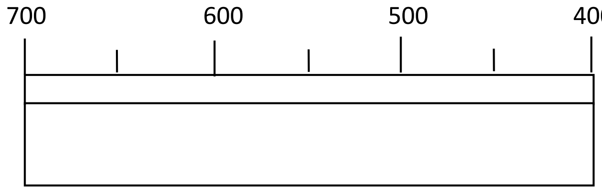
Description of the spectrum



17

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

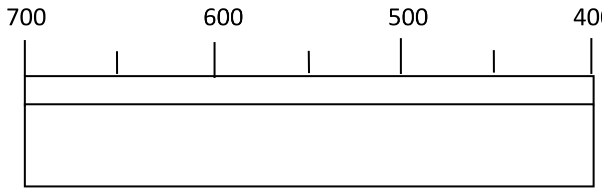
Description of the spectrum



18

Specimen No: …………	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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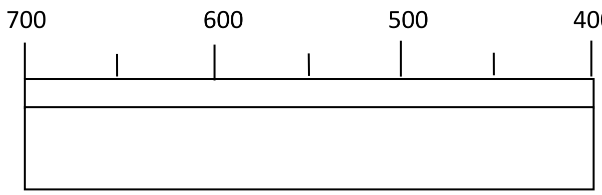
19

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

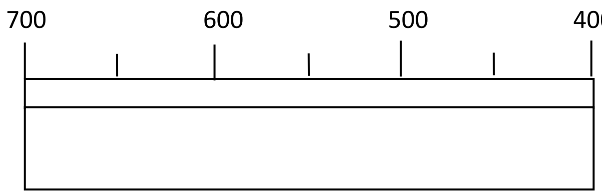
Description of the spectrum



20

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

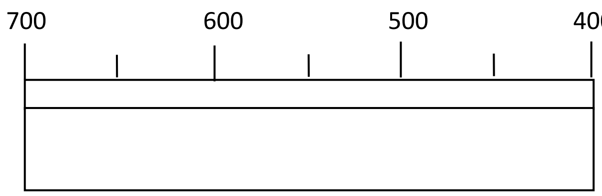
Description of the spectrum



21

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum



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22

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

23

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

24

Specimen No:	Describe and sketch the absorption spectrum seen under diffraction spectroscope

Description of the spectrum

700 600 500 400

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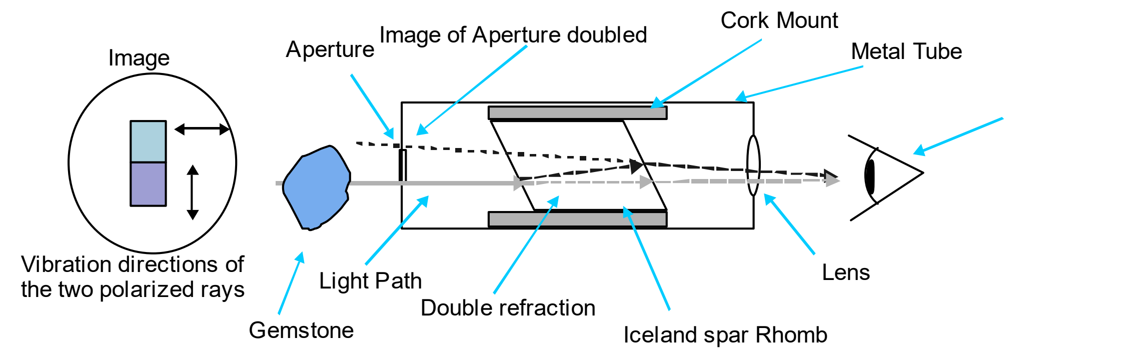
7. Dichroscope:

The Construction and Functions:

Dichroscope consists of a cleaved rhomb of Iceland spar, a transparent colourless variety of calcite, which is mounted in a metal tube. At one end is the eyepiece and at the other end is a square aperture. When looking through the eyepiece at a light source, preferably indirect daylight, two images- square windows - are seen side by side, as a result of the two plane polarized rays.



The Construction of the Dichroscope

When polarization directions of the two rays of a double refractive coloured gemstone coincide with those of the dichroscope, two colours or shades appear from the two windows, which can be seenside by side.

Dichroism is not seen in the following;

a. In any colourless gemstone, eg. diamond.
b. In any white or black opaque stone, eg. marble or onyx.
c. In all isotropic gem materials, ie. singly refractive stones,
d. In double refractive gemstones, if the direction of view coincides with an optic axis, eg in uniaxial gemstones along the c-axis.
e. In double refractive gemstones, if the directions of polarization of the gemstone and those of the calcite rhomb of the dichroscope are at 45° to each other.
f. In all polycrystalline gemstones, since the minute crystals are disorderly oriented.

Pleochroism in a gemstone should be observed under three conditions;

i. The degree or strength of pleochroism, which vary greatly according to species and varieties. eg. Very strong pleochroism in andalusite iolite and tanzanite.
Strong pleochroism in ruby and sapphire.
Moderate in apatite.
Weak in zircon.

ii. The number of colours or shades of colour, whether two or three colour.

iii The typical colour of gem varieties, eg. red, yellow and green in andalusite

violetish blue, light blue and straw yellow in iolite.

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Pleochroism is helpful to observe the following;

a. To separate double refractive gems from single refractive ones.
b. To separate uniaxial (dichroic) gemstones from biaxial (trichroic) ones.
c. To identify gem varieties to in some instances, by observing the degree of dichroism, the typical colour and also the number of colour or shades.
d. To bring all the colours to the best advantage as in andalusite, or best one colour as in ruby in lapidary activities.
e. To obtain the maximum shade in light coloured gemstones or the minimum shade in dark coloured gemstones as in the case of tourmalines in lapidary activities.

As the instrument shows only two colours at a time, the gemstone should be looked at least in two directions of orientation at 90° to each other to observe if any three colours are visible.

The following behaviours may be observed from the dichroscope;

a. If two squares show identically the same colours or shades in any direction, the stone is, probably, but not certainly singly refractive.

b. If the two squares show different colours or even different shades of the same tint, then the stone is pleochroic and must be double refractive.

c. Not all coloured anisotropic materials show pleochroism. Absence of pleochroism does not mean that the material is isotropic. All biaxial materials may not show trichroism clearly and depending on the degree of pleachroism, some species and specially light coloured varieties may show only a slight difference in the same colour

Gemstone Sp[ecies-Variety	Body Colour	Pleochroic Character	Degree of Pleochroism	Colurs
Andalusite	Green to reddish	Trichroic	Moderate	Reddish brown/Green/Yellow
Axinite	Brown	Trichroic	Strong	Reddish brown/Purple/Yellow
Beryl- Emerald	Green	Dichroic	Moderate	Bluish green / Yellowish green
Beryl-Aquamarine	Blue	Dichroic	Moderate	Colourless to Greenish/Blue
Chrysoberyl --Alexandrite	Daylight- Green Tungsten light-Red	Trichroic	Strong	Daylight- Green/Purplish red/Yellow Tungsten light- Green/Orange/Red
Chrysoberyl	Brown	Trichroic	Strong	Brown/Green/Yellow
Corundum Ruby	Red	Dichroic	Strong	Violetish red/ Orangish red
Corundum-Blue sapphire	Blue	Dichroic	Strong	Violetish blue/Greenish blue
Iolite	Blue	Trichroic	Very strong	Violetish blue/ Light blue/ Pale yellow
Quartz- Amethyst	Purple	Dichroic	Moderate	Mauve/ Reddish purple
Topaz	Blue	Dichroic to trichroic	Moderate	Moderate blue/ Male blue
Tourmaline	Blue	Dichroic	Strong	Light blue/Dark blue
Tourmaline	Red, blue, green	Dichroic	Strong	Light to dark of the body colour
Zoisite- Tanzanite	Blue to Violetish blue	Trichroic	Very strong	Violetish blue/Violetish pink/Yellowish green

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Practical training for Observation with Dichroscope

No	Gem specimen	Observation

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8. Chelsea Colour Filter.

This is simple filter with two gelatine layers which can transmit two limited areas of red and yellow-green of the visible spectrum. This was first used to separate emerald from its simulants.
Through this filter emerald shows red fluorescence due to chromium as its colouring element, and most other green stones appear green. But synthetic emerald also appears red due to chromium. Other stones coloured by chromium also show red effect

Gemstones coloured by cobalt also show red fluorescence. Cobalt produced body colour in gems and related materials such as synthetic blue spinel, natural rare blue spinel containing cobalt and blue glass, all of which show red fluorescence. Other blue coloured gemstones by other elements do not show similar effect.

Effect seen under Chelsea Colour Filter

Gemstone	Body Colour	Effect	Colouring Element
Emerald- Natural or synthetic	Green	Bright re, pinkish or greenish (some).	Cr
Alexandrite	Green / red	Pink to red	Cr
Demantoid garnet	Green	Pink to red	Cr
Jadeite, Chrome	Green	Pink	Cr
Chrysoprase	Green	Green	Nickel
Soude' emerald	Green	Most - dull green	Green cement
Blue Sapphire-Natural/synthetic	Blue- violet-blue	Dark green- mostly	Iron
Aquamarine	Blue to sea-green	Greenish blue	Iron
Blue spinel- natual	Blue	Reddish to grayish green	Iron
Blue spinel- synthetic	Blue	Strong to dark red, pink	Cobalt
Blue topaz- treated	Blue	Pale flesh or pale yellow	
Blue glass	Blue	Deep red to pink	Cobalt
Blue quartz	Blue	Deep red to pink	Cobalt
Ruby- natural and synthetic	Red	Red to bright red	Chromium
Garnet- pyrope-almandine	Bright red	Dark grey to gark red	Iron
Red glass	Red	Dark rde	

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Practical training for Observation with Chelsea Colour Filter

No	Gem specimen	Observation

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9. Luminescence under Ultraviolet Light

Ultraviolet is the part of the electromagnetic spectrum between 400 nm and 10 nm, the region between visible light and X-rays. These light rays are produced by special lamps, and in gem testing, the unwanted visible rays are then removed by filters.

Two ranges of ultraviolet light are used, with the following principal peak waves;

Long wave (LWUV) - 365 nm
Short wave (SWUV) - 254 nm

The fluorescent effects shown can be useful as a pointer towards other suitable tests or as a back-up to observations already done.

The specimen should be cleaned and placed on a black non-reflecting pad to observe under ultraviolet light, It should not be held by fingers or tweezers. Ultra-violet is dangerous to the eyes. The operator should never look directly at an ultra-violet lamp. Therefore the effect is observed indirectly. Ultra-violet can affect the colour of some gemstones, for instance in some zircons.

Only certain gemstones produce fluorescence. The effects vary with the presence of certain elements or crystal structure defects, which depends on the material's origin. The following gemstones fluorescent effects which will be useful in identification;

Diamond: Several colours, specially blue, yellow, green and pink in different shades are produced from one specimen to the other in a parcel of diamond. Cape series of white to yellow diamonds produce blue fluorescence with a yellow phosphorescence.

Diamond simulants: GGG produces peach colour fluorescence, YAG with yellow effect and Cubic Zirconia with pale yellow or pink effect.

Chromium bearing gem materials, both of natural and synthetic growth display red fluorescence in varying intensity. The presence of iron reduces this effect. Under this group are ruby, emerald, alexandrite, red spinel and pink topaz. Natural ruby produces less effect due to presence of iron, than by synthetic counterpart.

Most white and yellow sapphires from Sri Lanka produce orange or apricot fluorescence. But some specimens are inert, while some others, with low iron content, specially due to heat treatment, fluoresce with green colour.

Synthetic blue sapphire by Verneuil method produce chalky green or bluish-white fluorescence under short wave ultra violet. But modern synthetics do not produce this effect and appear similar to some natural counterparts.

Synthetic blue spinel produces dark red fluorescence due to cobalt, and similar effect is seen in rare blue spinel containing cobalt. Natural blue spinel is inert.

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Practical Observation with Ultra Violet Light

No	Gem specimen	Observation

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10. Specific Gravity Measurement and Weight Estimation of Gemstones

Weight

Weights of gemstones are expressed in carats usually to the second decimal place.

Specific Gravity

Specific gravity (S.G.) can be measured by hydrostatic weighing. Comparison of the Specific gravity of a gemstone can be done with that of another by heavy liquid method. Observation of SG of a gemstones is only a guide leading to other test, than an exact identification.

Hydrostatic Weighing;

Weigh the stone in air in a scale. Take the results (A). Weigh the stone fully immersed in water. Record the result (W). The difference in weight between A and W is the loss of weight of the stone in water, which is also the weight of the volume of water loss by immersion of the stone.

$$SG = \frac{A}{A - W}$$

Weight estimation of gemstones

To obtain an approximate weight of a gemstone mounted in jewellery, the following weight estimation formulae will be useful.

The stone should be measured in millimeters to obtain the length(L), width(W) and depth(D). For round stones, maximum and minimum diameter and depth (D)

Shape and Cut	Formula
Round, faceted	Weight = (Average diameter)^2 x D x SG x 0.0018
Oval, faceted	Weight = $\left(\frac{L+W}{2}\right)^2$ x D x SG x 0.0020
Marquise, faceted	Weight = L x W x D x SG x 0.0019
Pear, faceted	Weight = L x W x D x SG x 0.0020
Heart, faceted	Weight = L x W x D x SG x 0.0019
Step rectangle, faceted	Weight = L x W x D x SG x 0.0030
Emerald cut, faceted	Weight = L x W x D x SG x 0.0027
Cabochon cut	Weight = L x W x D x SG x 0.0026 (Shallow cabochons= 0.0029)

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Spaces for training in weight estimation

Cut	Gemstone	Formula	Weght

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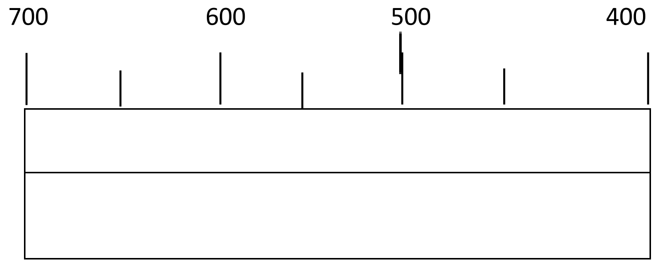
Practical work book Module A

General Observation and Testing of Gemstones

1.

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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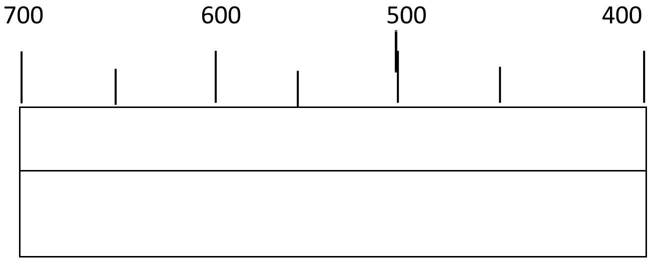
General Observation and Testing of Gemstones

2.

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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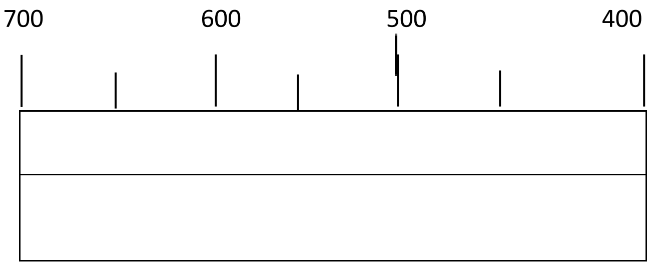
General Observation and Testing of Gemstones

3.

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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4. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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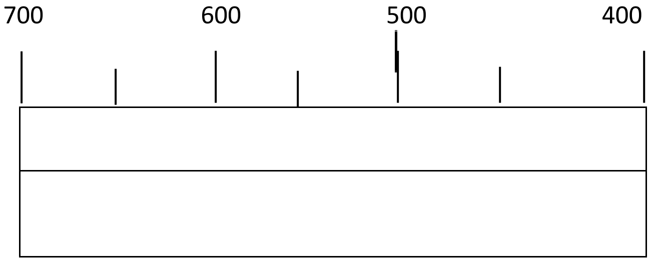
5. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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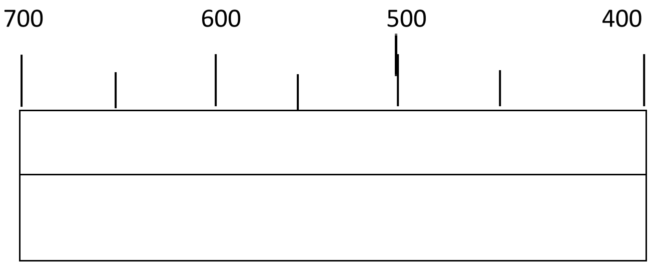
6. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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7. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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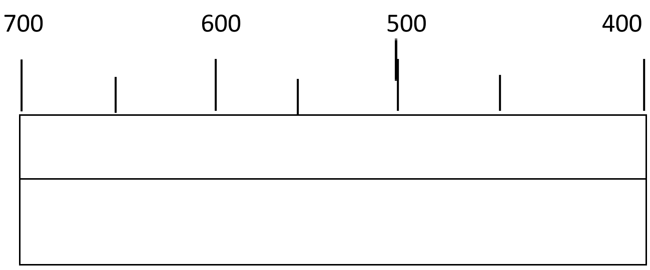
8. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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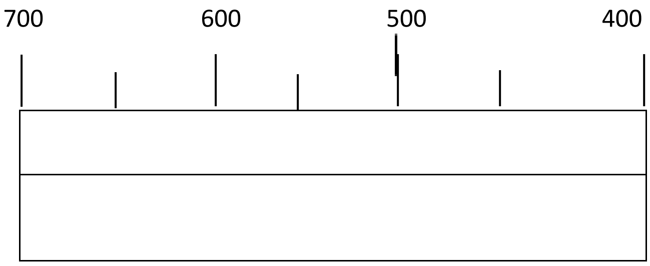
9. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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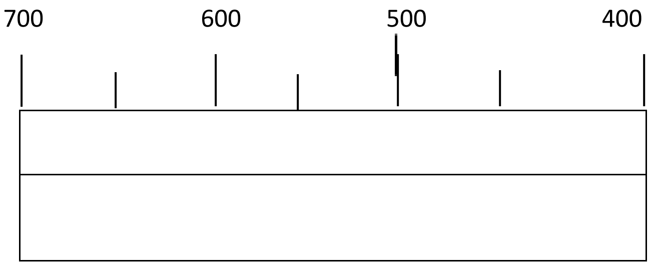
10. General Observation and Testing of Gemstones

Specimen No: ………..	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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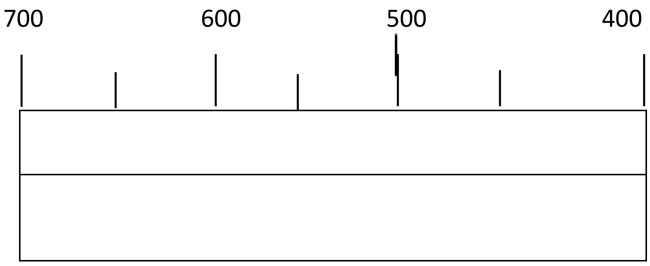
11. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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12. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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13. General Observation and Testing of Gemstones

Specimen No: ………..	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

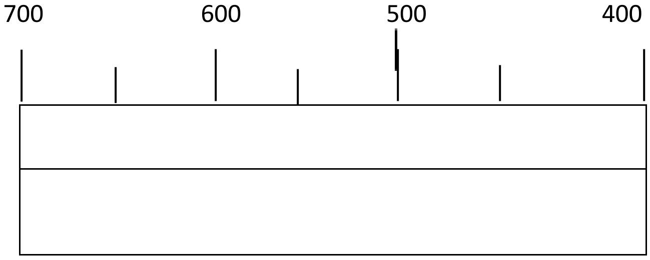
Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

ATC/Gemmologist ,Stamp, Date and Signature

14. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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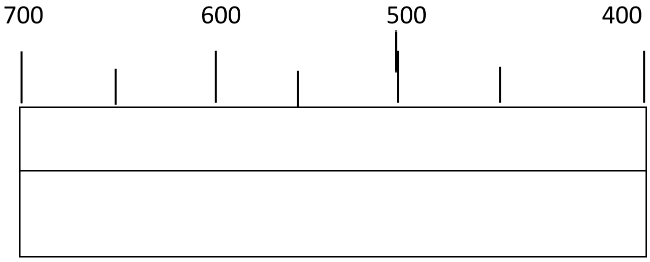
15. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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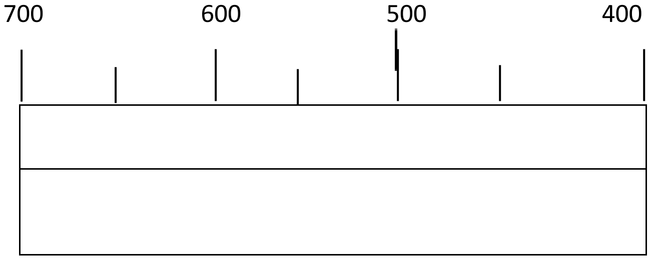
16. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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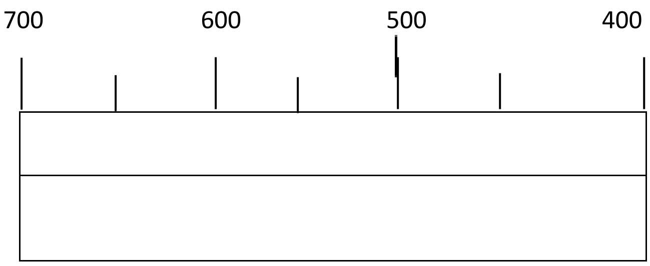
17. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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18. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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19. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen

700 600 500 400

Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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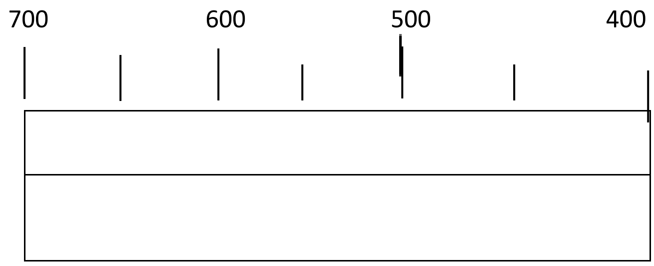
20. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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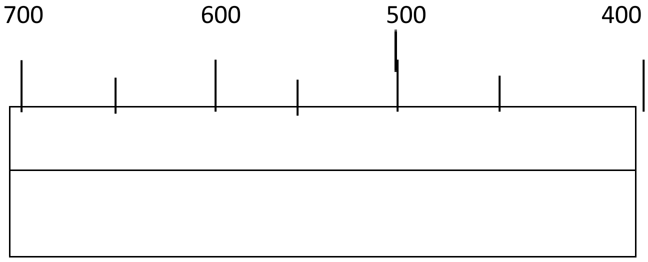
21. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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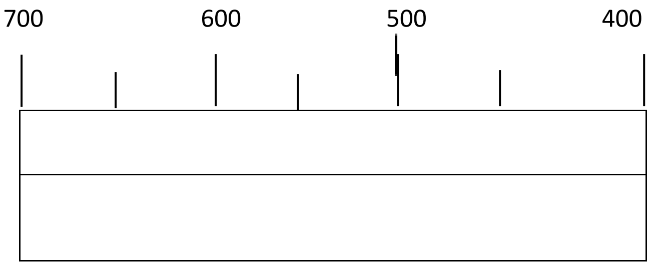
22. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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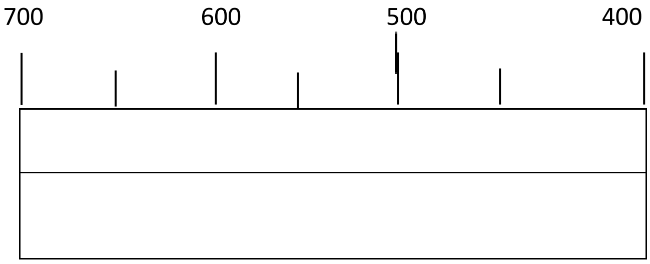
23. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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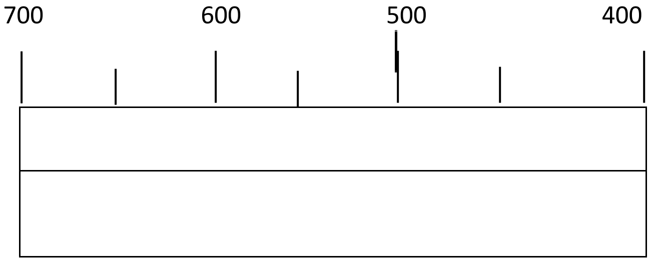
24. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone…………………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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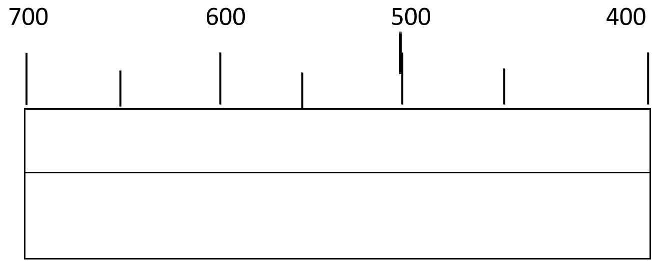
25. General Observation and Testing of Gemstones

Specimen No: …………	Make observations and Tests. Identify the specimen



Observation with spectroscope, if applicable

Conclusion- Indentify the Gemstone……………………………………………………………………………………………..

Indicate the Gem species and varitey. Identify the nature of the stone (natural, synthetic or artificial) and any observable treatment

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CONSTANTS OF SYLLABUS STONES LISTED IN REFRACTIVE INDEX ORDER

A copy of this list of constants in RI order is given to, students at the beginning of the diploma practical exam.

Each range of RI, birefringence or SG covers the typical values for that material. Certain specimens may have values outside the ranges listed here.

I - Isotropic, U - Uniaxial, B – Biaxial

Material	RI	Birefringence	Optical Char.	SG	H
Opal	1.40 to 1.46	-	I	2.0 to 2.2	6
Fluorite	1.43 to 1.44	-	I	3.0 to 3.2	4
Sodalite	1.48 approx	-	-	2.3 approx	5½ to 6
Calcite varieties	1.48 to 1.66	0.172	U-	2.58 to 2.75	3
Lapis lazuli	1.50 approx	-	-	2.7 to 2.9	5½
Glass, Natural	1.50 approx	-	I	2.4 approx	5 to 5½
Glass, Artificial (Paste)	1.50 to 1.70	-	I	2.0 to 4.2	6 approx
Gypsum varieties	1.52 to 1.53	-	B+	2.3 approx	2
Feldspar varieties	1.52 to 1.57	0.004 to 0.009	B+/-	2.56 to 2.75	6
Quartz, polycrystalline	1.53 to 1.55	-	-	2.6 approx.	6 to 7
Ivory, dentine	1.53 to 1.57	-	-	1.7 to 2.0	2 to 3
Amber	1.54 approx.	-	I	1.05 to 1.10	2½
Ivory, vegetable	1.54 approx	-	-	1.4 approx.	2½
Quartz, crystalline	1.54 to 1.56	0.009	U+	2.65 approx.	7
Scapolite	1.54 to 1.58	0.009 to 0.026	U-	2.50 to 2.74	6
lolite	1.54 to 1.56	0.008 to 0.012	B-	2.57 to 2.61	7 to 7½
Steatite	1.55 approx	-	-	2.7 to 2.8	1
Tortoiseshell	1.55 approx.	-	-	1.29	2½
Serpentine, bowenite	1.56 approx	-	-	2.6 approx	2 - 4
Beryl varieties	1.56 to 1.60	0.003 to 0.010	U-	2.65 to 2.80	7½
Rhodochrosite	1.59 to 1.82	0.220	U-	3.5 to 3.7	4
Topaz	1.61 to 1.64	0.008 to 0.010	B+	3.5 to 3.6	8
Actinolite	1.61 to 1.65	0.020 to 0.025	B-	3.10	5 to 6
Nephrite	1.62 approx	-	-	2.8 to 3.1	6½
Turquoise	1.62 approx.	-	-	2.6 to 2.9	75½ to 6
Tourmaline	1.62 to 1.65	0.014 to 0.021	U-	3.0 to 3.1	7 to 7½
Andalusite	1.63 to 1.64	0.007 to 0.013	B-	3.15 to 3.20	7½
Danburite	1.63 to 1.64	0.006	B+	3.00	7

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Apatite	1.63 to 1.64	0.002 to 0.006	U-	3.17 to 3.23	5
Enstatite	1.65 to 1.67	0.009 to 0.012	B+	3.25	5½
Phenakite	1.65 to 1.67	0.016	U+	2.95	7½ to 8
Peridot	1.65 to 1.69	0.036	B+/-	3.32 to 3.37	6½
Ekanite	1.597	-	3.28		6 to 6½
Jadeite	1.66 approx.	-	-	3.30 to3.36	7
Jet	1.66 approx.	-	-	1.3 approx.	2½ to 4
Spodumene	1.66 to 1.68	0.015 to 0.016	B+	3.17 to 3.19	7

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Material	RI	Birefringence	Optical Char.	SG	H
Sillimanite	1.66 to 1.68	0.014 to 0.021	B+	3.24	6 to 7½
Axinite	1.67 to 1.69	0.010 to 0.012	B-	2.29	6½ to 7
Kornarupine	1.67 to 1.69	0.012 to 0.017	B-	3.32	6½
Diopside	1.67 to 1.70	0.024 to 0.030	B+	3.26 to 3.32	5½
Sinhalite	1,67 to 1.71	0.037 to 0.038	B-	3.47 to 3.50	6½
Tanzanite	1.69 to 1.70	0.006 to 0.013	B+	3.15 to 3.38	6 ½
Garnet, Hydrogrossular	1.70 t0 1.73	-	I	3.3 to 3.6	7¼
Kyanite	1.71 to 1.73	0.015 to 0.017	B-	3.62	4½ to 7
Spinel, Natural	1.71 to 1.74	-	I	3.58 to 3.61	8
Idocrase (Vesuvianite)	1.71 to 1.72	0.002 – 0.005	U+/-	3.40	6½
Taaffeite	1.71 to 1.73	0.004 to 0.009	U-	3.61	8
Rhodonite.	1.72 apprx	-	-	3.6 to 3.7	6
Spinel, Verneuil synthetic	1.72 to1. 73	-	I	3.61 to 3.67	8
Garnet, Grossular	1.73 to 1.75	-	I	3.4 to 3.8	7¼
Garnet, Pyrope	1.74 to 1.76	-	I	3.7 to 3.8	7¼
Chrysoberyl	1.74 to 1.76	0.008 to 0.010	B+	3.71 to 3.75	8½
Benitoite	1.75 to 1.80	0.047	U+	3.64	6 - 6½
Corundum varieties	1.76 to 1.78	0.008 to 0.009	U-	3.80 to 4.05	9
Garnet, Almandine	1.76 to 1.81	-	I	3.8 to 4.2	7½
Zircon	1.78 to 1.99	Up to 0.059	U+	3.9 to 4.8	6½ to 7½
Garnet, Spessartine	1.79 to 1.82	-	I	4.12 to 4.20	7¼
YAG	1.83 approx.	-	I	4.6 approx	8
Malachite	1.85 approx.	-	-	3.6 to 4.0	4
Sphene	1.88 to 2.05	0.105 to 0.135	B+	3.4 to 3.6	5 to 5½
Garnet, Demantoid	1.89 approx.	-	I	3.82 to 3.85	6½
Scheelite	1.92 to 1.94	0.015	U+	6.06 to 6.30	4½ - 5
Cubic Zirconia	2.17 approx.	-	I	5.6 to 6.0	8 to 8½
Diamond	2.42	-	I	3.52	10
Strontium Titanate	2.409	-	I	5.13	6
Ruitle, Synthetic	2.61 to 2.90	0.287	U+	4.26	6 to6½
Synthetic Moissanite	2.65 to 2.69	0.043	U	3.22	9¼
Hematite	-	-	-	5 approx.	5½ to 6½
Pyrite	-	-	-	5 approx.	6½

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CONSTANTS OF SYLLABUS STONES LISTED IN ALPAHEBETICAL ORDER OF GEMSTONE NAMES

The following list of constants is in alphabetical order of the gemstone names. Each range of RI, birefringence or SG covers the typical values for that material. Certain specimens may have values outside the ranges listed here.

I - Isotropic, U - Uniaxial, B – Biaxial

Material	RI	Birefringence	Optical Char.	SG	H
Actinolite	1.61 to 1.65	0.020 to 0.025	B-	3.10	5 to 6
Amber	1.54 approx.	-	I	1.05 to 1.10	2½
Andalusite	1.63 to 1.64	0.007 to 0.013	B-	3.15 to 3.20	7½
Apatite	1.63 to 1.64	0.002 to 0.006	U-	3.17 to 3.23	5
Axinite	1.67 to 1.69	0.010 to 0.012	B-	2.29	6½ to 7
Benitoite	1.75 to 1.80	0.047	U+	3.64	6 - 6½
Beryl varieties	1.56 to 1.60	0.003 to 0.010	U-	2.65 to 2.80	7½
Calcite varieties	1.48 to 1.66	0.172	U-	2.58 to 2.75	3
Chrysoberyl	1.74 to 1.76	0.008 to 0.010	B+	3.71 to 3.75	8½
Corundum varieties	1.76 to 1.78	0.008 to 0.009	U-	3.80 to 4.05	9
Cubic Zirconia	2.17 approx.	-	I	5.6 to 6.0	8 to 8½
Danburite	1.63 to 1.64	0.006	B+	3.00	7
Diamond	2.42	-	I	3.52	10
Diopside	1.67 to 1.70	0.024 to 0.030	B+	3.26 to 3.32	5½
Enstatite	1.65 to 1.67	0.009 to 0.012	B+	3.25	5½
Ekanite	1.597	-	3.28		6 to 6½
Feldspar varieties	1.52 to 1.57	0.004 to 0.009	B+/-	2.56 to 2.75	6
Fluorite	1.43 to 1.44	-	I	3.0 to 3.2	4
Garnet, Almandine	1.76 to 1.81	-	I	3.8 to 4.2	7½
Garnet, Demantoid	1.89 approx.	-	I	3.82 to 3.85	6½
Garnet, Grossular	1.73 to 1.75	-	I	3.4 to 3.8	7¼
Garnet, Hydrogrossular	1.70 t0 1.73	-	I	3.3 to 3.6	7¼
Garnet, Pyrope	1.74 to 1.76	-	I	3.7 to 3.8	7¼
Garnet, Spessartine	1.79 to 1.82	-	I	4.12 to 4.20	7¼
Glass, Natural	1.50 approx	-	I	2.4 approx	5 to 5½
Glass, Artificial (Paste)	1.50 to 1.70	-	I	2.0 to 4.2	6 approx
Gypsum varieties	1.52 to 1.53	-	B+	2.3 approx	2
Hematite	-	-	-	5 approx.	5½ to 6½

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Idocrase (Vesuvianite)	1.71 to 1.72	0.002 – 0.005	U+/-	3.40	6½
Iolite	1.54 to 1.56	0.008 to 0.012	B-	2.57 to 2.61	7 to 7½
Ivory, dentine	1.53 to 1.57	-	-	1.7 to 2.0	2 to 3
Ivory, vegetable	1.54 approx	-	-	1.4 approx.	2½
Jadeite	1.66 approx.	-	-	3.30 to3.36	7
Jet	1.66 approx.	-	-	1.3 approx.	2½ to 4
Kornarupine	1.67 to 1.69	0.012 to 0.017	B-	3.32	6½
Kyanite	1.71 to 1.73	0.015 to 0.017	B-	3.62	4½ to 7

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Material	RI	Birefringence	Optical Char.	SG	H
Lapis lazuli	1.50 approx	-	-	2.7 to 2.9	5½
Malachite	1.85 approx.	-	-	3.6 to 4.0	4
Nephrite	1.62 approx	-	-	2.8 to 3.1	6½
Opal	1.40 to 1.46	-	I	2.0 to 2.2	6
Peridot	1.65 to 1.69	0.036	B+/-	3.32 to 3.37	6½
Phenakite	1.65 to 1.67	0.016	U+	2.95	7½ to 8
Pyrite	-	-	-	5 approx.	6½
Quartz, polycrystalline	1.53 to 1.55	-	-	2.6 approx.	6 to 7
Quartz, crystalline	1.54 to 1.56	0.009	U+	2.65 approx.	7
Rhodochrosite	1.59 to 1.82	0.220	U-	3.5 to 3.7	4
Rhodonite.	1.72 apprx	-	-	3.6 to 3.7	6
Ruitle, Synthetic	2.61 to 2.90	0.287	U+	4.26	6 to6½
Scapolite	1.54 to 1.58	0.009 to 0.026	U-	2.50 to 2.74	6
Scheelite	1.92 to 1.94	0.015	U+	6.06 to 6.30	4½ - 5
Serpentine, bowenite	1.56 approx	-	-	2.6 approx	2 - 4
Sillimanite	1.66 to 1.68	0.014 to 0.021	B+	3.24	6 to 7½
Sinhalite	1,67 to 1.71	0.037 to 0.038	B-	3.47 to 3.50	6½
Sodalite	1.48 approx	-	-	2.3 approx	5½ to 6
Sphene	1.88 to 2.05	0.105 to 0.135	B+	3.4 to 3.6	5 to 5½
Spinel, Natural	1.71 to 1.74	-	I	3.58 to 3.61	8
Spinel, Verneuil synthetic	1.72 to1. 73	-	I	3.61 to 3.67	8
Spodumene	1.66 to 1.68	0.015 to 0.016	B+	3.17 to 3.19	7
Steatite	1.55 approx	-	-	2.7 to 2.8	1
Strontium Titanate	2.409	-	I	5.13	6
Synthetic Moissanite	2.65 to 2.69	0.043	U	3.22	9¼
Taaffeite	1.71 to 1.73	0.004 to 0.009	U-	3.61	8
Tanzanite	1.69 to 1.70	0.006 to 0.013	B+	3.15 to 3.38	6 ½
Topaz	1.61 to 1.64	0.008 to 0.010	B+	3.5 to 3.6	8
Turquoise	1.62 approx.	-	-	2.6 to 2.9	75½ to 6
Tortoiseshell	1.55 approx.	-	-	1.29	2½
Tourmaline	1.62 to 1.65	0.014 to 0.021	U-	3.0 to 3.1	7 to 7½
YAG	1.83 approx.	-	I	4.6 approx	8
Zircon	1.78 to 1.99	Up to 0.059	U+	3.9 to 4.8	6½ to 7½

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Gemmologists Association of Sri Lanka

Diploma Practical Examination

December 2015

Paper 1

Time : One and half hours

Instruction to candidate:

- The candidate's index number must be written in the answer book. The name must not be written
- Practical paper contains 3 questions.
- Answer all the questions.
- Clearly write the identification number of the specimen and write the answer
- Take only one specimen at a time
- Hardness tests not allowed.

Ql. Specimens 1-5

Identify and name the crystal specimens using their appearance

Describe each crystal specimen and record all observations only a 10x lens and a Light source is allowed.

Q2. Specimens 6-10

Identify and name the specimens using spectroscope

Draw the absorption lines in the box provided.

Q.3 Specimens 11-15

Identify the stone specimens and organic specimens using the equipments provided.

Record all your observations.

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Diploma Practical Examination

December 2015

Paper II

Time : Two and half hours

Instruction to candidate:

- The candidate's index number must be written in the answer book. The name must not be written
- Practical paper contains 3 questions.
- Answer all the questions.
- Clearly write the identification number of the specimen and write the answer
- Take only one specimen at a time
- Hardness tests not allowed.

Ql. Specimens 1-3

Measure the refractive Indices to three decimal places. Write the lowest and highest refractive indices, the birefringence, optical character and optic sign. You are not required to identify these stones.

Q2. Specimens 4-5

Identify the specimens using spectroscope.
Draw the absorption lines in the box provided.

Q3. Specimens 6-15

Identify the specimens using the equipments provided. Record all your observations

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Notes

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