The Gemmological Association of Great Britain

# Syllabus for the Diploma Examination

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# DIPLOMA SYLLABUS 1

## ◆ SYLLABUS FOR THE DIPLOMA EXAM

The Diploma examination consists of two theory papers of three hours and a practical paper of three and a half hours. Candidates must sit for both theory and practical papers on the specified dates in the one examination session (for re-sits, see above, under 'After the examination').

In exceptional circumstances a candidate may be allowed to take both Foundation and Diploma Examinations in one examination session. In such circumstances the permission of the Gemmological Association must be obtained before any form is submitted and the entry for the two Examinations must be made on separate forms.

*Please Note:* no Diploma grades are given and no Diploma is awarded if the candidate does not qualify in the Foundation Examination.

***The Diploma syllabus***
***comprises the whole of the Foundation (Sections 1 to 20)***
***as well as the Diploma (Sections 21 to 32)***

## FOUNDATION

### 1 Gem Materials

Nature and attributes of gems and ornamental materials; factors which influence the value of a stone: beauty, durability, rarity; acceptability. Earth's physical activity; melting, recrystallization, sedimentation, mineralization.

### 2 The Nature of Gem Materials

The origin and occurrence of gem minerals (elementary).
Major types of gem deposit (general description): pegmatite; diamond pipe; placer; hydrothermal vein.
Extraction: mining and recovery methods (outline only).
Minerals, atoms, elements and chemical bonding (elementary).

# 2 DIPLOMA SYLLABUS

## 3 Crystalline Materials

The nature of crystals; crystalline materials (outline only).
Polycrystalline (including microcrystalline) materials.
The existence of: reference (crystallographic) axes and crystal symmetry;
Crystal form, habit and twinning.
The names of the seven crystal systems.
The common and typical crystal forms for crystals in each of the systems.
Crystal observation
Amorphous and metamict materials; polymorphs; isomorphism.

## 4 Durability of Gem Materials

Hardness: definition and significance; testing and Mohs' scale; differential hardness.
Toughness and stability. Fracture; types of fracture.
Cleavage: definition, description and significance.

## 5 Specific Gravity

Density and specific gravity (SG). Definitions of density and SG.
SG measurement and hydrostatic weighing.
The simple use of high-density liquids in gem testing; care and caution in use.

## 6 The Nature of Light

The importance of light in gemmology.
The nature of light.
Wavelength and frequency.
The electromagnetic spectrum.
The visible spectrum of colour.
Polarization and vibration direction.

## 7 Refraction

Refraction; refractive index (RI), definition and description.
Singly refractive materials.
Doubly refractive materials: directional properties; double refraction,

polarization, optic axes.
Measurement of RI; the refractometer; the principle of total internal reflection; an outline of its main component parts.
The determination of birefringence using the refractometer.

## 8 Reflection and its Effects

External reflection: lustre. Examples of lustre.
Internal reflection effects caused by inclusions; chatoyancy and asterism.
Internal reflection effects caused by structural features.
Iridescence: interference and diffraction.
Brilliance.

## 9 Colour; the Visible Spectrum and the Spectroscope

Light and body colour in gemstones.
The visible spectrum.
Dispersion, 'fire' and diffraction.
Body colour and selective absorption of light.
Colouring elements.
The absorption spectrum and the spectroscope.

The use of the spectroscope.
The absorption spectra of the following materials:

| | |
|---|---|
| almandine garnet | emeraldzircon |
| peridot | rubyblue sapphire |
| red glass (selenium) | red glass (gold) |
| blue glass (cobalt) | blue Verneuil synthetic spinel (cobalt) |

Use of colour filters; the Chelsea colour filter.
Colour change effect ('alexandrite effect').

## 10 Polarized Light; the Polariscope and the Dichroscope

The nature of polarized light.
Isotropic and anisotropic behaviour; optic axes.
The production of polarized light; the polarizing filter; 'crossed' polarizing filters.
The polariscope and its and use; typical results;
Pleochroism; the dichroscope, and its use; typical results.

# 4 DIPLOMA SYLLABUS

## 11 Non-visible Radiation, Energy and Fluorescence

Luminescence: fluorescence.
Use of the ultra-violet lamp (short wave and long wave).
The use of X-rays in gemmology.
Thermal conductance and electrical conductivity probes; reflectance meters.
Summary of some important laboratory methods.

## 12 Optical Magnification

Magnification: the 10x lens and the microscope; lighting.
Observation of gem materials: internal and external features; immersion of gems to aid observation.

## 13 Description and Elementary Methods of Identification of Natural Inorganic Gem Materials

Chemical composition.
Crystal system and crystal habit.
Common and characteristic crystal forms, and crystal face markings and features.
Cleavage and fracture.
Hardness.
Specific gravity.
Colour; causes of colour; pleochroism.
Lustre.
Internal reflection effects (including iridescence, chatoyancy and asterism);
Refractive index (with birefringence).
Dispersion (description of relative amounts only).
Common and characteristic inclusions.
Major geological occurrences.
Major world localities of commercial deposits.
*of all gem varieties of the following:*

| | | |
|---|---|---|
| beryl | garnet | quartz (including chalcedony) |
| chrysoberyl | iolite | spinel |

| | | |
|---|---|---|
| corundum | jadeite | tanzanite |
| diamond | nephrite | topaz |
| feldspar | opal | tourmaline |
| fluorite | peridot | zircon |

The absorption spectra of selected materials (see Item 9).

## 14 Natural Gem Materials of Organic Origin

The formation and structure and methods of identification of natural and cultured pearl.

An elementary knowledge of the formation, properties and methods of identification of:

amber coral ivory jet shell tortoiseshell

## 15 Artificial Gem Materials

Artificial and synthetic gems: definitions.

A brief outline of methods of production and identification of materials produced by the Verneuil flame fusion, flux melt and hydrothermal methods.

Non-crystalline artificial materials: paste; plastics.

## 16 Imitation and Composite Gem Materials

Imitation (simulation) of gem and ornamental materials; the use of natural and artificial materials as imitations; the distinction of gem diamond from its simulants, particularly cubic zirconia (CZ).

Composite (assembled) natural and artificial stones; reconstructed materials.

## 17 Treated Gem Materials

Examples of methods of treatment (enhancement) and their identification, including dyeing, bleaching, impregnation, coating, irradiation, heating, laser treatment, fracture filling and diffusion treatment.

Additional Gem Materials

The most important distinguishing features of the following materials:

andalusite pyrite

apatite
calcite (Iceland spar; banded and massive ornamental varieties; marble)
glass - natural (included obsidian)
gypsum (including alabaster)
hematite
lapis-lazuli
malachite
rhodochrosite
rhodonite
serpentine bowenite
sodalite
spodumene
steatite (soapstone)
turquoise

### 18 Fashioning of Gemstones

Description of gemstone cuts: specifically the brilliant (with proportions for round brilliant-cut diamond); step (emerald) cut; mixed cut; cabochon cut.
A brief description of other common cuts.
Reasons for the use of various cuts.
Processes in lapidary and diamond manufacture.

### 19 Gems in jewellery

Gem settings in jewellery.
Gem identification and diamond grading reports.
The quality factors of gemstones.
Appraisal and valuation.
Testing gems in jewellery.

## DIPLOMA

### 20 The Nature of Gem Materials, their Origins and Occurrence

Chemical and biologically-derived components of gem materials.
Gem origins, and their relationship to rarity, beauty and acceptability.
Occurrences of gem materials.
The impact of new discoveries of gem deposits on the use of gem materials.

### 21 Structure and Properties of Gem Materials

Atomic-scale structure, electrons and chemical bonding.
The crystalline state and crystalline materials.

Crystal structures in terms of chemical bonding.
Structural isomorphism: 'isomorphous substitution'.
Crystalline polymorphism.
The relationship of crystal structure and symmetry to crystal faces, forms, habits, cleavage, internal growth phenomena and crystal surface markings; relevance to identification.

### 22 Colour in Gem Materials

Colour and its causes in gem materials; luminescence; diamond types.
Physical optics; optical phenomena that affect light.

### 23 Optical Properties; Advanced uses in Gem Testing

Optical properties of crystalline and non-crystalline gem materials.
The systematic interaction of light with crystal structures: pleochroism, polarization, optic axes and optic axial interference figures; uses in gem testing.
Refractive index, birefringence and optic sign: their measurement by refractometer and by other methods.
Dispersion: comparison in faceted gemstones; measurement not required.

### 24 The Electromagnetic Spectrum; Uses in Gem Testing; the Visible Spectrum and the Spectroscope

The electromagnetic spectrum.
Optical spectroscopy.
Spectra of gem materials in addition to those in the Foundation Syllabus.
Gem testing techniques employed in gemmological laboratories; X-ray, infrared, ultraviolet and advanced techniques.

### 25 Non-Optical Properties; Testing Techniques

Hardness and its use in testing.
Parting.
Thermal properties and the uses of thermal conductance probes in gem testing.
Electrical properties of gem materials.

# 8 DIPLOMA SYLLABUS

## 26 Specific Gravity

Accurate specific gravity measurement for gem testing.
The use of high density liquids.
Precautions in specific gravity testing.

## 27 Magnification Techniques; Internal and External Features

The uses of the lens and microscope in gem testing.
External features; internal features and the study of inclusions, in rough and fashioned natural, artificial, treated and imitation gem materials.

## 28 Artificial, Composite and Imitation (Simulant) Gem Materials

Single-crystal growth of artificial materials; nucleation; flame-fusion, flux-melt and hydrothermal.
Methods of production for Y.A.G., synthetic rutile, strontium titanite and synthetic moissanite.
An outline of the following production methods for artificial gem materials: skull melting process for cubic zirconia; Czochralski 'crystal pulling' method;'floating zone' (zone melting) method; high pressure high temperature synthesis of diamond
A brief outline of the production methods/manufacture of synthetic opal, turquoise, lapis lazuli, coral composite (assembled) materials and reconstructed materials.
(Descriptions, identification, detection: item 29)

## 29 Treated Gem Materials and Methods of Treatment

Details of methods of treatment in addition to those in the Foundation syllabus: heat treatment and surface diffusion; irradiation and annealing; HPHT diamond treatment.
Disadvantages and advantages of treatment or enhancement.
(Descriptions, identification, detection: item 29)

## 30 Description of Gem Materials of Inorganic Origin

The following information is required (where relevant, and as given in the course notes) for all gem materials listed below.

# DIPLOMA SYLLABUS 9

Properties listed in the Foundation syllabus item 12 with the addition (where applicable) of:

Characteristic crystal face markings and features
Absorption spectra
Luminescence
Birefringence with optical nature and optic sign
Separation of gem materials from their synthetics and most common simulants
Detection of treatment or enhancement

*of all gem varieties of the following*:

| | | |
|---|---|---|
| apatite | iolite | spinel |
| beryl | jadeite | tanzanite |
| chrysoberyl | nephrite | topaz |
| corundum | opal | tourmaline |
| diamond | peridot | zircon |

feldspar (moonstone, labradorite, amazonite and sunstone)
garnet group
quartz (including chalcedony)

The most important distinguishing features (those that aid identification) of the following gem and ornamental materials:

andalusite
calcite (Iceland spar; banded and massive ornamental varieties; marble)
cubic zirconia (CZ)
diopside
fluorite
glass - natural and artificial (including obsidian and moldavite)
gypsum (including alabaster)
hematite
hydrogrossular garnet
lapis-lazuli
malachite
synthetic moissanite
pyrite
rhodochrosite
rhodonite
synthetic rutile
scapolite
serpentine (including bowenite)
sinhalite
sodalite
sphene
spodumene
steatite
strontium titanite
turquoise

# 10 DIPLOMA SYLLABUS

Theory examination questions involving gem materials of inorganic origin will contain examples only from syllabus item 29.

### 31 Description of Gem Materials of Organic Origin

Origin, occurrence, recovery, methods of identification and common simulants of:

amber copal
coral ivory jet tortoiseshell
pearls: natural, cultured (nucleated and non-nucleated), marine and freshwater;
shell (particularly as used for cameos and as mother-of-pearl).

*Units of measurement essential to this course and examination:*

| | | |
|---|---|---|
| metric carat (ct) | metre (m) | litre (l) |
| pearl grain | millimetre (mm) | millilitre (ml) |
| kilogram (kg) | micrometre (µm) | cubic centimetre (cc) |
| gram (g) | nanometre (nm) | |
| milligram (mg) | temperature (°C) | |

# DIPLOMA SYLLABUS 11

## ◆ CONSTANTS OF SYLLABUS STONES LISTED IN ALPHABETICAL ORDER

A copy of this alphabetical list of constants is given to students at the beginning of the diploma *theory* 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 |
|---|---|---|---|---|---|
| | | | | | |
| 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 |
| 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 |
| 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 |
| 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 to 1.73 | - | I | 3.3 to 3.6 | 7¼ |
| Garnet, pyrope | 1.74 to 1.76 | - | I | 3.7 to 3.8 | 7¼ |

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| Material | RI | Birefringence | Optical Char. | SG | H |
|---|---|---|---|---|---|
| Garnet, spessartine | 1.79 to 1.82 | - | I | 4.12 to 4.20 | 7¼ |
| Gypsum varieties | 1.52 to 1.53 | - | B+ | 2.3 approx. | 2 |
| Hematite | - | - | - | 5 approx. | 5½ to 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 to 3.36 | 7 |
| Jet | 1.66 approx. | - | - | 1.3 approx. | 2½ to 4 |
| Lapis lazuli | 1.50 approx. | - | - | 2.7 to 2.9 | 5½ |
| Malachite | 1.85 approx. | - | - | 3.6 to 4.0 | 4 |
| Natural glass | 1.50 approx. | - | I | 2.4 approx. | 5 to 5½ |
| Nephrite | 1.62 approx. | - | - | 2.8 to 3.1 | 6½ |
| Opal | 1.40 to 1.46 | - | I | 2.0 to 2.2 | 6 |
| Paste (artificial glass) | 1.50 to 1.70 | - | I | 2.0 to 4.2 | 6 approx. |
| Peridot | 1.65 to 1.69 | 0.036 | B+/- | 3.32 to 3.37 | 6½ |
| Pyrite | - | - | - | 5 approx. | 6½ |
| Quartz, crystalline | 1.54 to 1.56 | 0.009 | U+ | 2.65 approx. | 7 |
| Quartz, polycrystalline | 1.53 to 1.55 | - | - | 2.6 approx. | 6 to 7 |
| Rhodochrosite | 1.59 to 1.82 | 0.220 | U- | 3.5 to 3.7 | 4 |
| Rhodonite | 1.72 approx. | - | - | 3.6 to 3.7 | 6 |
| Scapolite | 1.54 to 1.58 | 0.009 to 0.026 | U- | 2.50 to 2.74 | 6 |
| Serpentine, bowenite | 1.56 approx. | - | - | 2.6 approx. | 5 |
| 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 | 1.71 to 1.74 | - | I | 3.58 to 3.61 | 8 |
| Spinel, Verneuil synthetic | 1.72 to 1.73 | - | I | 3.61 to 3.67 | 8 |

# DIPLOMA SYLLABUS 13

| Material | RI | Birefringence | Optical Char. | SG | H |
|---|---|---|---|---|---|
| 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 |
| Synthetic moissanite | 2.65 to 2.69 | 0.043 | U | 3.22 | 9¼ |
| Tanzanite | 1.69 to 1.70 | 0.006 to 0.013 | B+ | 3.15 to 3.38 | 6½ |
| Topaz | 1.61 to 1.64 | 0.008 to 0.010 | B+ | 3.5 to 3.6 | 8 |
| 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 |
| Turquoise | 1.62 approx. | - | - | 2.6 to 2.9 | 5½ to 6 |
| 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 |