Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2022

PHYSICS AND CHEMISTRY – ORDINARY LEVEL

WEDNESDAY, 22 JUNE – MORNING, 9:30 to 12:30

Five questions to be answered.

Answer any **two** questions from Section I, any **two** questions from Section II and **one** other question from either Section I or Section II.

All the questions carry equal marks.

N.B. Relevant data are listed in the *Formulae and Tables* booklet, which is available from the superintendent.

Do not hand this up.

This document will not be returned to the State Examinations Commission.

The 2022 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

SECTION I – PHYSICS

1. Answer **eleven** of the following items (*a*), (*b*), (*c*), etc. All the items carry equal marks.
Keep your answers short.

(*a*) What is meant by potential energy?

(*b*) How long does it take a swimmer, moving at a constant speed of 1.5 m s^{-1}, to swim 50 m?

(*c*) **Figure 1** shows a 3 kg kettlebell.
Calculate the weight of the kettlebell.
[acceleration due to gravity, g = 9.8 m s^{-2}]

Figure 1

(*d*) Sketch a diagram to show diffraction of plane waves after passing through a narrow gap.

(*e*) How would you show that white light is composed of a mixture of colours?

(*f*) Give one use for a concave mirror.

(*g*) **Figure 2** shows a waveform.
What term is given to the distance marked **X**?

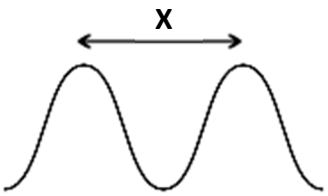

Figure 2

(*h*) What is meant by Brownian motion?

(*i*) State one assumption of the kinetic theory of gases.

(*j*) Identify the gas law that states that the product of pressure and volume (pV) of a fixed mass of gas is constant at a particular temperature.

(*k*) Convert 4.7 kiloohms (kΩ) to ohms (Ω).

(*l*) Copy and complete the following statement of Coulomb's law:
"The force between two point charges is proportional to the . . . . . of the charges and inversely proportional to the square of the . . . . . between them."

(*m*) Calculate the effective capacitance of a *parallel* arrangement of two 6 µF capacitors.

(*n*) What is meant by the photoelectric effect?

(*o*) **Figure 3** shows a bar magnet. Copy the diagram and sketch the magnetic field lines around the bar magnet.

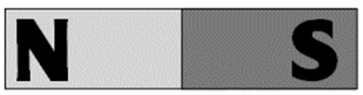

Figure 3

(*p*) Identify one method of detecting nuclear radiation.

(*q*) Iodine–131 has a half-life of 8 days.
What fraction of a sample of iodine–131 remains after 16 days?

(*r*) State Einstein's equation which relates energy and mass.

(11 × 6)

2. (*a*) (i) Define acceleration.
(ii) What is the S.I. unit of acceleration?
(iii) Define kinetic energy. (18)

Figure 4

(*b*) **Figure 4** shows a hippopotamus and her calf. The adult hippopotamus of mass 1,400 kg reached a velocity of 8 m s^{-1} starting from rest and accelerating uniformly for 5 seconds.

Calculate
(i) the acceleration of the adult hippopotamus
(ii) the distance covered by the adult hippopotamus in the 5 seconds
(iii) the time taken by the adult hippopotamus to move the first 10 metres
(iv) the maximum kinetic energy of the adult hippopotamus.

Why did the kinetic energy of the hippopotamus increase over the 5 seconds? (30)

(*c*) The hippopotamus calf of mass 180 kg accelerated uniformly as a result of its muscles producing a force of 220 N.
(i) What was the acceleration of the calf?
(ii) Did these two animals have the same kinetic energy when they had the same speed? Give a reason for your answer. (18)

3. (*a*) **Figure 5** shows a pair of convex lenses in reading glasses being used to magnify text. Reading glasses are an application of the refraction of light.
What is meant by the underlined term?
State the laws of refraction of light. (18)

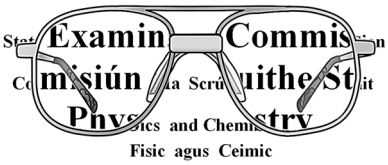

Figure 5

(*b*) **Figure 6** shows light rays from a *distant* object emerging from a convex lens. Redraw the diagram showing the rays as they *approach* the lens.
What term describes the point labelled **X**?
Describe a laboratory experiment to find the distance from **X** to the lens. (21)

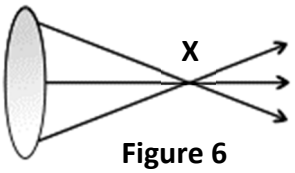

Figure 6

(*c*) Copy and complete **Figure 7** to show how a convex lens can form a magnified image.
Give one difference between this image and the type of image formed when using reading glasses. (15)

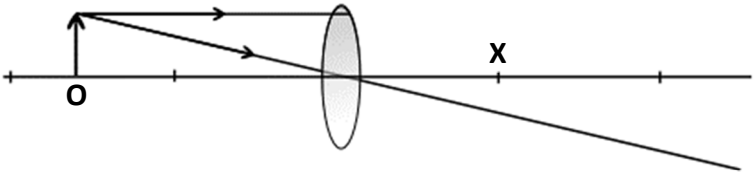

Figure 7

(*d*) **Figure 8** shows a ray of light entering a triangular glass prism and travelling through it.
(i) State the angle of incidence at **A**.
(ii) What phenomenon occurs at **B** and at **C**? (12)

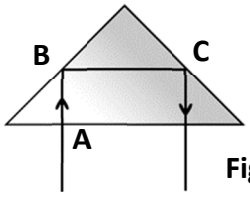

Figure 8

4. **Figure 9** shows two liquid-in-glass thermometers, a traditional clinical mercury thermometer and an alcohol-based laboratory thermometer.

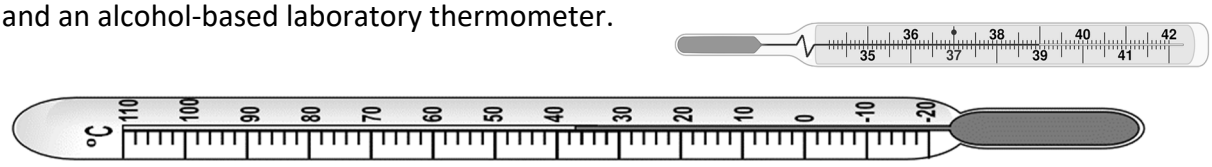

Figure 9

(*a*) The clinical thermometer measured a person's body temperature as 37 °C.
What is this temperature on the Kelvin scale?
Give one disadvantage of using mercury in a thermometer. (12)

(*b*) What is meant by a thermometric property?
What is the thermometric property on which all liquid-in-glass thermometers are based?
Give one example of a thermometer which uses a different thermometric property.
State the thermometric property on which your example is based. (24)

(*c*) State the temperatures on the Celsius scale assigned to the fixed points
(i) melting ice, (ii) the steam above boiling water.
A student noted that the length of the liquid inside an alcohol thermometer was 2.0 cm in an ice-water mixture and 10.2 cm in the steam above boiling water.
What is the difference in the length of liquid between the two fixed points?
Calculate the length of the liquid when this thermometer reads 37 °C. (30)

5. (*a*) **Figure 10** shows a miniature circuit breaker (mcb) and a fuse, two safety devices commonly used in household electrical circuits.
The mcb uses the magnetic effect of a current.
Give **two** other effects of an electric current.
How does the fuse work as an electrical safety device? (15)

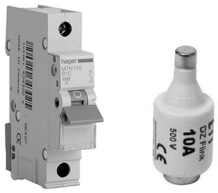

Figure 10

(*b*) The table below records the electrical energy consumption of a water heater over a one-hour period.

Energy (kW h)	0	0.4	0.8	1.2	1.8	2.4
Time (minutes)	0	10	20	30	45	60

Draw a graph (on graph paper) of energy (*y*-axis) against time (*x*-axis).
How much electrical energy was consumed every 15 minutes? (18)

(*c*) **Figure 11** shows a 6 Ω resistor and a 2 Ω resistor connected in series with a battery.
The ammeter in the circuit gave a reading of 3.0 A when the switch was closed.

(i) Explain why the reading would also be 3.0 A if the ammeter was placed between the two resistors.

(ii) State Ohm's law.

Calculate

(iii) the effective resistance of the two resistors

(iv) the voltage (potential difference) across the 6 Ω resistor

(v) the voltage of the battery in the circuit. (33)

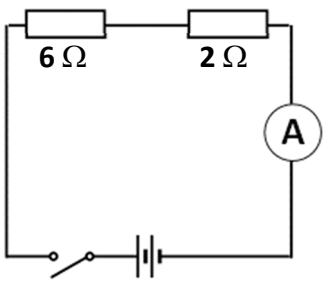

Figure 11

6. Answer any **two** of the following parts (*a*), (*b*), (*c*), (*d*). Each part carries 33 marks.

(*a*) State the *principle of conservation of momentum*. (9)

Figure 12 shows two skateboards each of mass 5.2 kg on a smooth horizontal surface. Skateboard **A** moving at 0.85 m s^{-1} collides with skateboard **B** which is at rest. Both skateboards move in the same direction after the collision and the speed of skateboard **A** is now 0.37 m s^{-1}.

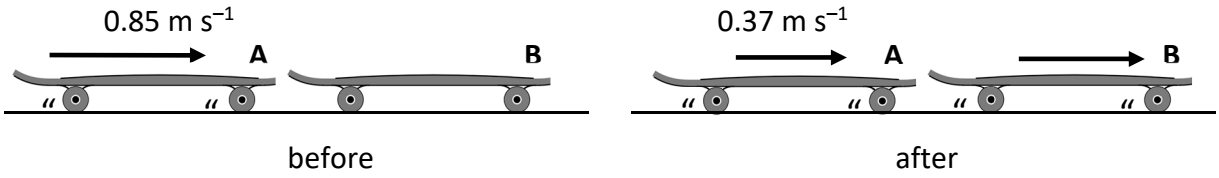

Figure 12

Calculate
(i) the momentum of skateboard **A** *before* the collision
(ii) the momentum of skateboard **A** *after* the collision
(iii) the momentum of skateboard **B** *after* the collision
(iv) the speed of skateboard **B** *after* the collision. (24)

(*b*) **Figure 13** shows party balloons that are filled with helium gas. All the helium gas on Earth was formed from alpha particles released during radioactive decay of some unstable nuclei.

In terms of subatomic particles, what is the composition of an alpha particle?
How many electrons must an alpha particle gain to form an atom of helium? (12)

Figure 13

Give one way to change the direction of a stream of moving alpha particles.
State a precaution to be taken when handling a source of alpha particles.

Identify **two** other types of radiation released during radioactive decay of unstable nuclei. (21)

(*c*) Consider the descriptions in the table about electromagnetic induction.

A	S.I. unit named after the scientist who discovered electromagnetic induction
B	A device that uses electromagnetic induction to change the size of an alternating voltage
C	Type of current in a wire that gives rise to a steady magnetic field
D	Type of charge on a subatomic particle carrying a current in a metallic conductor
E	S.I. unit used to measure the size of an induced voltage
F	A device that converts mechanical energy into electrical energy
G	Type of current which is detected by the oscillation of a galvanometer needle

In your answerbook match each term below with its description (**A**, **B**, **C**, **D**, **E**, **F** or **G**) in the table.

alternating **direct** **dynamo** **farad**
negative **transformer** **volt** (21)

Describe how you could demonstrate electromagnetic induction. (12)

(*d*) Draw a labelled diagram of a gold leaf electroscope.

How would you use a negatively charged electroscope to determine if a charged plastic rod was also negatively charged? (18)

Figure 14 shows a positively charged rod held near two neutral conducting spheres on insulated stands, with the spheres in contact.

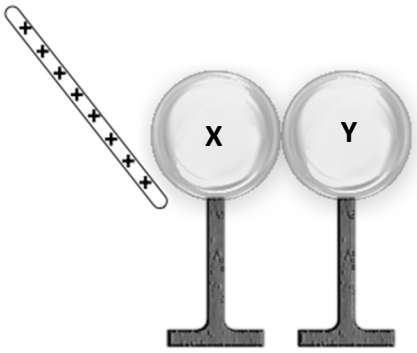

Figure 14

Sphere **Y** was moved to the right and then the rod was removed.

State the net charge now on sphere **X**.
Explain your answer.

State the net charge on sphere **Y** after it was earthed. (15)

SECTION II – CHEMISTRY

7. Answer **eleven** of the following items (*a*), (*b*), (*c*), etc. All the items carry equal marks. *Keep your answers short*.

(*a*) Sketch the shape of a *p*-orbital.

(*b*) **Figure 15** represents graphene, an allotrope of the element carbon. What are allotropes?

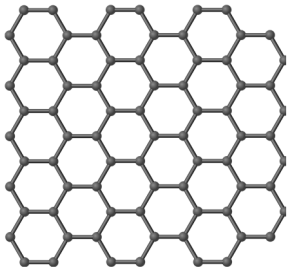

Figure 15

(*c*) Select **two** noble gases from the following:
hydrogen helium nitrogen oxygen argon

(*d*) What is meant by a standard solution?

(*e*) Give one characteristic property of transition metal compounds.

(*f*) Calculate the percentage by mass of magnesium in magnesium nitride (**Mg_3N_2**).
[N = 14, Mg = 24]

(*g*) Arrange the following metals in order of *increasing* ease of oxidation:
aluminium sodium zinc

(*h*) Give one characteristic property of metallic crystals.

(*i*) Identify the type of bond *between* water molecules represented by the broken lines in **Figure 16**.

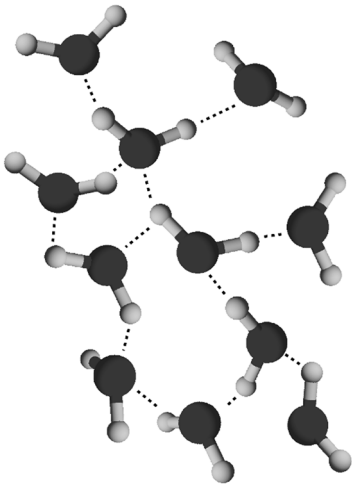

Figure 16

(*j*) Define reduction in terms of transfer of electrons.

(*k*) Copy, complete and balance the following equation:
Na_2SO_3 + HCl → NaCl + _____ + H_2O

(*l*) State Hess's law.

(*m*) What is meant by an *endothermic* reaction?

(*n*) Give an example of (i) an acidic oxide, (ii) a basic oxide.

(*o*) How many atoms, of which element, are lost when a molecule of ethanol (**C_2H_5OH**) is oxidised to a molecule of ethanal (**CH_3CHO**)?

(*p*) Identify the functional group in a ketone.

(*q*) Why are the compounds whose structures are shown in **Figure 17** both classified as aromatic alcohols?

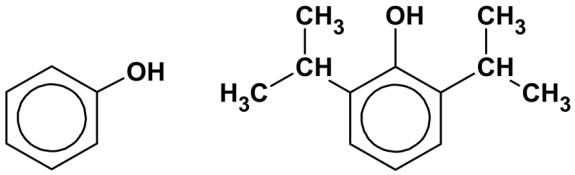

Figure 17

(*r*) What two organic compounds react to form the ester ethyl ethanoate (**$CH_3COOC_2H_5$**)?

(11 × 6)

8. (*a*) $^{35}_{17}\mathbf{Cl}$ is the most abundant of the isotopes of the element chlorine.

Explain the underlined terms. (12)

State the number of (i) protons, (ii) neutrons, found in an atom of this isotope.

Write the electron configuration (*s*, *p*) for an atom of chlorine. (18)

(*b*) Define electronegativity.

Use electronegativity values (on page 81 of the *Formulae and Tables* booklet) to predict the type of bonding found in hydrogen bromide (**HBr**). (12)

Copy **Figure 18**, that represents a single molecule of **HBr**, into your answerbook and mark clearly on your diagram

(i) a partial negative charge

(ii) a partial positive charge.

(iii) Would you expect **HBr** to be soluble in water? Explain your answer.

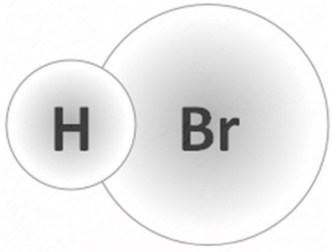

Figure 18

(iv) At room temperature, would you expect **HBr** to be a crystalline solid with a high melting point? Explain your answer. (24)

9. (*a*) Hydrogen produced by the electrolysis of acidified water is called 'green hydrogen' if renewable electricity is used, e.g. electricity generated from wind turbines similar to those in **Figure 19** located in Drumkeeran, County Leitrim.

Figure 19

Figure 20 shows apparatus used to electrolyse acidified water in the laboratory.

Name an unreactive material suitable for use as the electrodes **X** and **Y**.

At which electrode does oxidation occur?

What gas is collected at (i) **A**, (ii) **B**?

Describe a test to confirm the identity of the gas at **B**.

Give one commercial use for this gas. (33)

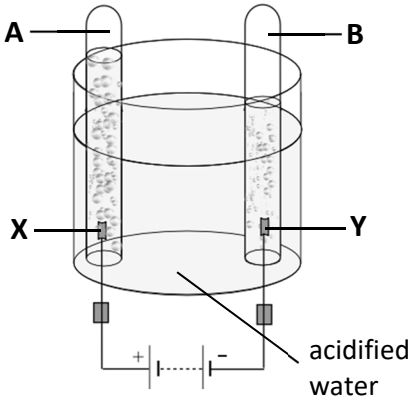

Figure 20

(*b*) State the Brønsted-Lowry definition of

(i) an acid, (ii) a base.

What is meant by a *weak acid*?

Identify **two** acids in the following equation:

$\mathbf{NH_3 + H_2S \rightleftharpoons NH_4^+ + HS^-}$ (21)

What information does the pH value of a solution give about it?

Calculate the pH of a 0.039 M solution of nitric acid (**HNO_3**). (12)

10. Some glassware used to titrate a solution of sodium hydroxide (**NaOH**) with a hydrochloric acid (**HCl**) solution, and then separate the salt **NaCl** from the neutralised solution, is shown in **Figure 21**.
The balanced equation for the titration reaction is:

HCl + NaOH → NaCl + H_2O

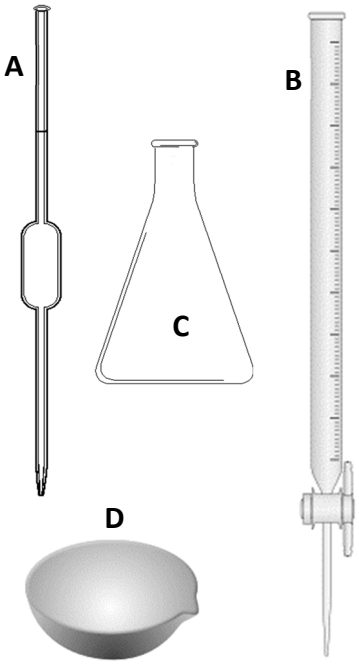

Figure 21

(*a*) (i) Name **two** pieces of personal protective equipment (PPE) worn when using chemicals in a laboratory.

(ii) Identify **A** and **B**.

(iii) Describe how **A** is prepared for use in this titration.

(iv) Give one precaution to ensure accuracy when taking a reading from **B**. (36)

When carrying out a number of titrations of the **NaOH** with the **HCl** a few drops of substance **X** were added to conical flask **C** containing the base but **X** was omitted from the final titration.

(*b*) (i) Name a suitable substance for use as **X**.

(ii) What is the purpose of adding **X**?

(iii) Suggest a reason why **X** was omitted from the final titration.

(iv) Find the concentration of the sodium hydroxide solution used if 25.0 cm^3 portions of it required, on average, 22.9 cm^3 of 1.13 M **HCl** for neutralisation. (18)

(*c*) (i) What process occurs in **D** that separates the salt from the neutralised solution?

(ii) Give a common use for the salt **NaCl**. (12)

11. The outdoor space heater shown in **Figure 22** is fuelled by propane (C_3H_8) contained in a cylinder in its base. Propane is the third member of a homologous series of <u>hydrocarbons</u>.

(*a*) (i) Explain the underlined term.

(ii) Name the homologous series to which propane belongs.

(iii) Give the name of the first member of this homologous series.

(iv) Give **two** physical properties of these members of this homologous series. (27)


Figure 22

(*b*) (i) Why is propane described as a *saturated* hydrocarbon?

(ii) Propane is converted to 2-chloropropane when it reacts with Cl_2. Draw the structures of the propane and 2-chloropropane molecules.

(iii) Is the conversion of propane to 2-chloropropane an addition, an elimination, or a substitution reaction? (21)

(*c*) Propane burns according to the following balanced equation:

C_3H_8 + $5O_2$ → $3CO_2$ + $4H_2O$ $\Delta H = -2{,}219$ kJ mol^{-1}

When 5 moles of propane are completely burned, calculate

(i) the quantity of energy released

(ii) the number of moles of carbon dioxide produced. (18)

12. Answer any **two** of the following parts (*a*), (*b*), (*c*). Each part carries 33 marks.

(*a*) **Figure 23** shows a laboratory set-up to prepare oxygen by the decomposition of a certain liquid and to collect test-tubes of the gas formed.

(i) Identify liquid **A** and solid **B**.

(ii) What is the purpose of **B**? (15)

(iii) Describe how a glowing wooden splint could be used to confirm the presence of oxygen in one of the test-tubes of gas collected.

(iv) What compound is produced if a sample of magnesium metal is burned in oxygen?

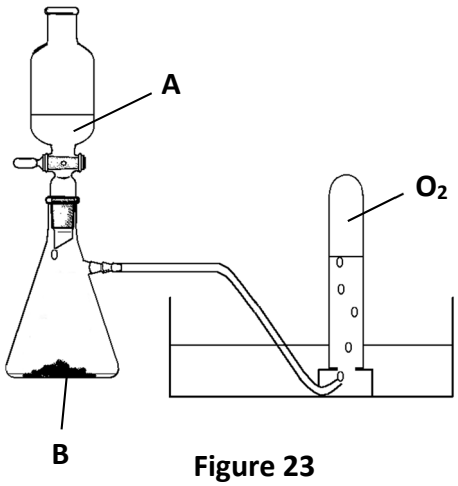

Figure 23

(v) Give one commercial use for oxygen gas. (18)

(*b*) The valence electrons around a central atom in a molecule determine its shape.

Explain the difference between a bonding pair of electrons and a lone pair of electrons in a molecule. (9)

Copy and complete the following table: (18)

Molecule	Number of bonding pairs	Number of lone pairs	Shape of molecule
H_2S		2	
BF_3		0	
NH_3	3		

Sketch a diagram to show the arrangement of any bonding pairs and lone pairs in the valence shell of nitrogen in a molecule of ammonia (**NH_3**). (6)

(*c*) **Figure 24** shows a loaf of Irish soda bread made from a recipe which includes the ingredients bread soda and buttermilk.

Figure 24

Lactic acid (**$C_3H_6O_3$**) in the buttermilk reacts with the sodium hydrogencarbonate (**$NaHCO_3$**) in the bread soda according to the following balanced equation:

$$C_3H_6O_3 + NaHCO_3 \rightarrow C_3H_5O_3Na + H_2O + CO_2$$

The carbon dioxide produced in the reaction above is trapped in the unbaked bread dough in small bubbles.

What is meant by a mole of a substance?

Find the mass of one mole of sodium hydrogencarbonate (**$NaHCO_3$**). (12)

[H = 1, C = 12, O = 16, Na = 23]

When a teaspoon measure (5 g) of **$NaHCO_3$** completely reacts according to the equation above, calculate

(i) the number of moles of **$NaHCO_3$** used

(ii) the number of water molecules produced

(iii) the volume of **CO_2** gas produced, measured in litres at s.t.p.

[Avogadro constant = 6.0×10^{23} mol^{-1}; molar volume at s.t.p. = 22.4 litres]

What would you expect the effect on the bubbles of **CO_2** to be, if the bread dough mixture is put in a pre-heated oven? (21)

Image Q1(*c*) on page 2: from www.dkn-uk.com
File: dkn-3kg-vinyl-kettlebell.jpg, accessed 19 November 2021

Image Q2 on page 3: by Ann van Breemen from
www.nationalgeographic.com/animals/mammals/facts/hippopotamus
File: https://i.natgeofe.com/n/e277f0d5-81af-404a-a21c-77f135f28a3d/6272462.jpg?w=636&h=636
accessed 19 November 2021

Image Q4 on page 4: www.needpix.com
File: photo/download/101946/thermometer-medical-clinical-thermometer-temperature-measurement-sick-instrument-health-scale, accessed 19 November 2021

Images Q5(*a*) on page 4: www.hager.ie and www.topline.ie
Files: ecatimages/thumb/NBN106A.jpg and images/productimages/519871547736.jpg,
accessed 23 November 2021

Image Q7(*b*) on page 7: from www.wikimedia.org
File: wikipedia/commons/thumb/1/10/Graphene.svg/1887px-Graphene.svg.png,
accessed 18 November 2021

Image Q9(*a*) on page 8: from Oliver Dixon at https://s2.geograph.org.uk
File: photos/00/00/000014_bfd815d0_213x160.jpg, accessed 18 November 2021

Image Q11 on page 9: from www.tilemerchant.ie
File: sunglo-stainless-steel-14kw-gas-patio-heater-with-regulator-hose-and-cover.jpg,
accessed 18 November 2021

Image Q12(*c*) on page 11: from Nora at www.savorynothings.com
File: traditional-irish-soda-bread.jpg, accessed 18 November 2021

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Leaving Certificate – Ordinary Level

Physics and Chemistry

Wednesday, 22 June
Morning, 9:30 – 12:30