Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE 2010

MARKING SCHEME

PHYSICS & CHEMISTRY

HIGHER LEVEL

General Guidelines

In considering this marking scheme the following points should be noted.

1. In many instances only key words are given, words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.

2. Marks shown in brackets represent marks awarded for partial answers as indicated in the scheme.

3. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable.

4. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.

5. The descriptions, methods and definitions in the scheme are **not** exhaustive and alternative valid answers are acceptable. Marks for a description may be obtained form a relevant diagram, depending on the context.

6. Where indicated, 1 mark is deducted for incorrect/ no units.

7. Each time an arithmetical slip occurs in a calculation, one mark is deducted.

8. The context and the manner in which the question is asked and the number of marks assigned to the answer in the examination paper determines the detail required in any question. Therefore, in any instance, it may vary from year to year.

Question 1

Any eleven parts <u>**11×3**</u>

(*a*) Define displacement. <u>**2×3**</u>
distance …3
in a given direction / vector …3

(*b*) State *Newton's first law of motion.* <u>**2×3**</u>
an object remains at constant velocity / an object remains at constant speed in a straight line …3
unless acted upon by an (external) force …3

(*c*) Define the unit of work, i.e. *the joule*. <u>**2×3**</u>
(work done when) one newton moves …3
(an object) one metre …3
[correct definition of work …3]

(*d*) Name two optical phenomena that occur when white light passes through a prism as shown in Figure 1. <u>**5, 1**</u>
dispersion
refraction or deflection or bending
first correct…5
second correct…1

(*e*) Give two properties of the image formed by reflection of an object in a plane mirror. <u>**5, 1**</u>
same size as object, same distance behind mirror as object is in front, laterally inverted, virtual, upright
first correct…5
second correct…1

(*f*) Figure 2 shows a ray of light entering an optical fibre. How does light travel through the fibre? <u>**2×3**</u>
total internal …3
reflection …3
[diagram alone…3]

(*g*) What type of wave is a water wave? Justify your answer. <u>**2×3**</u>
transverse / mechanical …3
medium or water (molecules) move(s) perpendicular to direction of propagation / method of generation involves (physical) movement of a body of water …3

(*h*) Small particles are observed to be in continuous agitation when suspended in a liquid or a gaseous medium, e.g. smoke particles in air. Name this phenomenon. <u>**2×3**</u>
Brownian …3
motion / movement …3

(*i*) State two assumptions of the kinetic theory of gases. **<u>5, 1</u>**

large number of particles or molecules, particles or molecules have negligible volume, in constant motion, in rapid motion, in random motion, in straight line motion, collide with one another, collide with walls of the container, collisions elastic or involve neither loss nor gain of energy, collision times of short duration, no interaction between particles or molecules except during collisions first correct…5

second correct…1

(*j*) Sketch the electrical field around a small, isolated, positively charged sphere. **<u>2×3</u>**

field lines correctly drawn radiating from a small positive charge …3

directional arrows correctly shown pointing away from positive charge …3

(*k*) State two factors that affect the capacitance of a parallel plate capacitor. **<u>5, 1</u>**

common area of plates, distance between plates, (permittivity of) medium between plates

first correct…5

second correct…1

(*l*) Figure 3 shows a conducting rod suspended between the poles of a strong magnet. The lower end of the conductor dips into mercury. Why does the conductor move when the current is switched on? **<u>6</u>**

(conductor carrying current in a magnetic field) experiences a force …6

(*m*) Sketch a graph to show the variation of an a.c. voltage with time. **<u>2×3</u>**

axes labelled voltage and time …3

sine wave

(*n*) What is *nuclear fission*? **<u>2×3</u>**

splitting of a large nucleus ...3

into two (smaller) nuclei …3

(*o*) The following fusion nuclear reaction takes place in the sun:

$$^{2}_{1}\mathbf{H} \quad + \quad ^{2}_{1}\mathbf{H} \quad \rightarrow \quad ^{4}_{2}\mathbf{He} \quad + \quad \mathbf{energy}$$

Explain why a large quantity of energy is produced in this reaction. **<u>2×3</u>**

(small) mass lost // binding energy ...3

(converted into large quantity of energy by) $E = mc^2$ // released ...3

[$E = mc^2$ alone …3]

Question 2

Define (i) *mass* **<u>3</u>**

a body's ability to resist motion / a measure of a body's inertia / amount of matter in a body …3

(ii) *weight* **<u>2×3</u>**

product of mass // force …3

and acceleration due to gravity// due to gravity …3

or

(*W* =) *mg* **…6**

[omit to explain *m*, *g* (–1)]

State *Newton's law of universal gravitation*. **<u>2×3</u>**

force is proportional to the product of two masses …3

and inversely proportional to the square of the distance between them …3

or

$$F = G\frac{m_1 m_2}{r^2} / F \propto \frac{m_1 m_2}{r^2} / \ F = G\frac{m_1 m_2}{d^2} / F \propto \frac{m_1 m_2}{d^2}$$ …6

[omit to explain symbols used *F*, *m*, *G*, *r* or *d* (–1)]

[$W = mg$ or $F = mg$ …3]

What is the relationship between *G*, the gravitational constant, and *g*, the acceleration due to gravity at the surface of the earth? **<u>5, 1</u>**

$$g = \frac{Gm}{r^2} \ / \ g = \frac{Gm}{d^2}$$ …5

where *m* is the mass (of the earth) and *r* is the radius (of the earth) or *d* is distance (from object to earth's centre)

(can allow same symbols explained above) …1

A student carried out an experiment to measure the acceleration due to gravity, *g*.

Draw a labelled diagram of a suitable apparatus. **<u>3×3</u>**

string, bob // ball, trapdoor // free falling object …3

point of suspension // electromagnet // light gates …3

correctly arranged …3

[no diagram (–1)]

State what measurements were made and how a value for *g* was obtained from these measurements. **<u>3×3</u>**

length of pendulum // distance fallen / distance between light gates …3

time for n oscillations // time for fall / t_1 and t_2 …3

use formula $T = 2\pi\sqrt{\frac{l}{g}}$ / find slope from graph *l* versus T^2 // use formula $s = \frac{1}{2}gt^2$ / find slope from graph *s* versus t^2 …3

A child threw a ball vertically up into the air. When the ball fell down it struck the ground. Ignoring the effect of air resistance, state an energy conversions that occurred:

(i) as the ball was rising through the air **3**

kinetic energy to potential energy …3

[energies reversed …2][either energy mentioned…1]

(ii) as the ball was falling to the ground **3**

potential energy to kinetic energy …3

[energies reversed …2][either energy mentioned…1]

(iii) as the ball struck the ground? **3**

(kinetic energy) to heat / sound / vibrational energy …3

The ball left the child's hand at a height 1.5 m above the ground and its initial velocity was 7.0 m s^{-1} upwards.

(i) the time taken for the ball to reach its maximum height above the ground **2×3**

$v = u + at$ / $0 = 7 - 9.8t$ …3

$t = 0.7(14)$ s …3

[no unit or incorrect unit (–1)]

(ii) the maximum height of the ball above the ground **2×3**

$v^2 = u^2 + 2as$ / $mgh = ½mv^2$ / $s = ½(u + v)t$ …3

$(0)^2 = (7)^2 - 2 \times 9.8 \times s$ / $m9.8h = ½m(7)^2$ / $s = ½(7 + 0)0.714$, $s = 2.5$ m/ $h = 2.5$ m

2.5 + 1.5 = 4.0 m …3

[omits to add 1.5 (–1)] [no unit or incorrect unit (–1)]

(iii) the maximum kinetic energy of the ball that had a mass of 0.2 kg. **2×3**

$mgh = ½mv^2$ 3

$0.2 \times 9.8 \times 4 = 7.84$ J …3

[no unit or incorrect unit (–1)] [4.9 J (–1)]

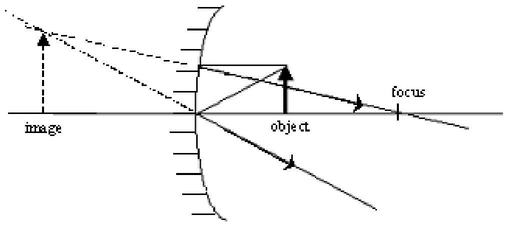
Question 3

(a) What is meant by (i) reflection of light **<u>3</u>**
bouncing or deflection backwards (of light when it impinges on a suitable surface) …3

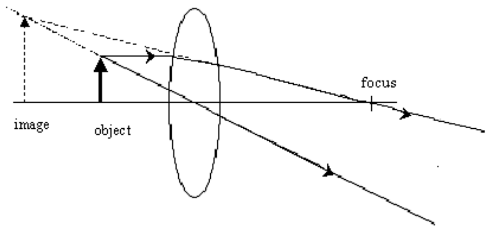
(ii) refraction of light? **<u>2×3</u>**
bending or deflection or changing of direction (of light) …3
as it passes from one medium to another …3

(b) Draw diagrams to show the formation of the image when an object is placed:

(i) inside the focus of a concave mirror **<u>6, 2×3</u>**
object shown inside labelled focus of concave mirror …3
one rays reflected correctly …6
(projected back to form) upright magnified image behind the mirror …3



(ii) inside the focus of a converging lens. **<u>2×3</u>**
object shown inside focus labelled (on either side of) converging lens
one rays refracted correctly
(projected back to form) upright magnified image on same side of lens as object
any two …2×3



(c) Describe in terms of light rays, the difference between a real image and a virtual image. **<u>2×3</u>**
real image formed when rays intersect …3
virtual image formed when rays appear to intersect …3
[real on a screen, virtual cannot appear on a screen, real inverted, vitual upright …3 max]

(d) Describe with the aid of a labelled diagram an experiment to measure the focal length of a concave mirror. **<u>5×3</u>**
concave mirror, pin, search pin //concave mirror, ray box, screen …3
diagram to show correct arrangement …3
locate image by no parallax //bring image in sharp focus on screen …3
measure object distance and image distance …3
use formula $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ / use graph of $\frac{1}{v}$ versus $\frac{1}{u}$ / where pin and image are equidistant from mirror
half this distance is the focal length …3

[approximate method …maximum 6]

(e) A dentist uses a concave mirror, like that shown in Figure 4 to examine a tooth. The mirror has a focal length of 2.4 cm and is held at a distance 2.0 cm from the tooth.

Calculate: (i) the distance between the mirror and the image of the tooth; **<u>2×3</u>**

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \,/\, \frac{1}{2.4} = \frac{1}{v} + \frac{1}{2.0}$$ **…3**

$$\frac{1}{2.4} - \frac{1}{2} = -\frac{1}{12} \Rightarrow v = 12\,\textbf{cm}$$ **…3**

[no unit or incorrect unit (–1)]

(ii) the magnification produced by the mirror. **<u>2×3</u>**

$$m = \frac{v}{u}$$ …3

$$m = \frac{12}{2} = 6 \text{ (or } -6\text{)}$$ …3

(f) A dentist can also use converging lenses fitted to plane glasses, as shown in Figure 5, to produce a magnified image of a tooth. The focal length of each lens is 33 cm and each lensis 28 cm from the tooth. Describe the image formed. **<u>5, 1</u>**

virtual

upright

first correct…5
second correct…1

Question 4

(*a*) A thermometric property, two reference temperatures and a scale are required to measure temperature. Give an example of a thermometric property. **<u>6</u>**

volume of a liquid, height of liquid or mercury or alcohol (in a column), resistance of metal, resistance of a semiconductor, pressure of a gas at constant volume, volume of a gas at constant pressure, product of pressure and volume of a gas, emf generated in thermocouple, etc. any one …6

What are the two reference temperatures used to establish the Celsius scale? **<u>2×3</u>**

melting (point of) ice / 0 ºC / 273 K …3

boiling (point of) water / 100 ºC / 373 K …3

[no unit or incorrect unit (–1)]

Describe how each of these temperatures be achieved in the laboratory. **<u>2×3</u>**

(mixture of) ice in water / melting ice …3

(steam above) boiling water …3

[idea of ice *melting* omitted (–1)]

The lower reference point of the Kelvin temperature scale is <u>absolute zero</u>.
Explain the underlined term. **<u>6</u>**

(the temperature at which) an ideal gas has no volume/ a real gas has minimal volume / the movement
of the molecules is minimal or stopped / the lowest temperature (theoretically) possible / –273 ºC …6

(*b*) **State Boyle's law.** **<u>2×3</u>**

the pressure of a fixed mass of gas is inversely proportional …3
to its volume at constant temperature …3
or
$P \propto 1/V$ / PV is a constant / $P_1V_1 = P_2V_2$ …3
at constant temperature …3
[omit to explain P and V (–1)]

What is an ideal gas? **<u>2×3</u>**

obeys gas laws / Boyle's law / satisfies kinetic theory assumptions …3
at all temperatures and pressures …3

Figure 6 shows an apparatus used by a student to verify Boyle's law. To obtain the data shown in the table below, the volume of the fixed mass of gas *V* was measured at different values of pressure, *P*.

P/kPa	101	150	175	200	225	250
V/cm^3	20.0	13.1	11.2	10.2	8.8	8.0

Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume. **4×3**

axes labelled *P* and 1/*V* / (accept *V* and 1/*P*) …3

correct scales kPa and cm^{-3} / (cm^3 and kPa^{-1}) …3

five points plotted correctly / inverse values plotted …3

suitable straight line through the origin …3

[allow marks for *P* versus *V*, axes labelled kPa and cm^3, five points plotted correctly, suitable curve]

Explain how your graph verifies Boyle's law. **2×3**

straight line …3

through the origin …3

[no marks available here for *P* versus V graph]

Use the slope of your graph to calculate the number of moles of argon gas trapped in the apparatus when the room temperature was 290 K. **6, 3, 3**

find slope using graph or using one data point and origin if graph line drawn through that point …6

$PV = nRT$ / slope = nRT …3

slope = $n \times 8.3 \times 290$, $n = 0.00083$ …3

[Any incorrect multiple of 0.00083 (–1)]

Question 5

Define electric current. **<u>3</u>**
flow of charge / flow of electrons …3

Distinguish between *direct current* and *alternating current*. **<u>2×3</u>**
direct current flow in one direction (in a circuit) …3
alternating current reverses direction periodically …3

State Ohm's law. **<u>2×3</u>**
current is proportional to // $V = IR$ or $V \propto I$ …3
potential difference at constant temperature // at constant temperature …3
[omit to explain terms (–1)]

A mobile phone contains a rechargeable 3.7 V battery that supplies *direct current* to the phone's electrical circuits.
Calculate
(i) the effective resistance of the arrangement of resistors in one of the phone's circuits that is shown in Figure 7 **<u>3×3</u>**
400 + 350 = 750 (Ω) …3

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{500} + \frac{1}{750}$$ …3

$R = 300\ \Omega$ …3
[no unit or incorrect unit (–1)]

(ii) the current *I* flowing in this circuit **<u>2×3</u>**
$V = IR$ …3
$3.7 = I \times 300 = 0.01(2)$ A …3
[no unit or incorrect unit (–1)]

(iii) the electrical energy used by this circuit in 30 seconds. **<u>2×3</u>**
$E = RI^2t$/ $E = +VIt$ …3
$E = 300 \times (0.012)^2 \times 30 = 1.296$ J / $E = 3.7 \times 0.012 \times 30 = 1.332$ (0.9 – 1.369 J) …3
[no unit or incorrect unit (–1)]

The phone's battery can be recharged by connecting the phone to a charger plugged into the mains supply. The charger contains a transformer.

Explain the operation of a transformer. **5×3**

primary coil, secondary coil and iron core described or drawn …3

core laminated or made of soft iron …3

a.c. / alternating supply /emf / current in primary …3

produces (alternating) supply or emf or current in the secondary …3

by electromagnetic induction …3

changing (magnetic) flux (links primary and secondary) …3

output voltage or current depends of relative numbers of turns in secondary and primary …3

any five …5 ×3

The transformer in the phone charger has 1200 turns in the primary coil and is connected to the 230 V mains supply.

Calculate the number of turns required in the secondary coil to generate an output of 4.6 V. **2×3**

$$\frac{n_s}{n_p} = \frac{V_s}{V_p}$$ …3

$$\frac{n_s}{1200} = \frac{4.6}{230} \Rightarrow n_s = 24$$ …3

How could the transformer be modified to generate a higher output voltage? **3**

more turns in secondary / fewer turns in primary …3

Give one way of reducing energy losses in a transformer. **6**

laminate the core, use a soft iron core, use core easily magnetised and demagnetised, reduce eddy currents, use suitably shaped core, use wires of low resistance, use thick wires on low voltage side, wind more tightly, etc. any one…6

Question 6
Answer any two parts.

Question 6(*a*)

Distinguish between a vector and a scalar. **2×3**
scalar has magnitude only …3
vector (has magnitude) and direction …3

Define momentum. **2×3**
product of mass *mv* …3
and velocity // explain *m*, *v* …3
or *mv*
[omit to explain *m*, *v* (–1)]

State *Newton's third law of motion.* **2×3**
for every action …3
there is an equal reaction / there is an equal and opposite force …3

A tennis ball of mass 0.06 kg, moving horizontally in an easterly direction at 20 ms^{-1}, struck a vertical wall and bounced back horizontally at a speed of 15 ms^{-1}.
Calculate the change in momentum when the ball bounced off the wall. **3×3**
0.06 × 20 = 1.2 (kg ms^{-1}) …3
0.06 × (–)15 = (–) 0.9 (kg ms^{-1}) (west or backwards or negative answer) …3
1.2 – – 0.9 = (–) 2.1 kg ms^{-1} / 2.1 kg ms^{-1} (west or backwards or negative answer) …3
[no unit or incorrect unit (–1)]
[0.3 kg ms^{-1} …6]

Does the *principle of conservation of momentum* apply in this case? Justify your answer. **3, 3**
no // yes …3
not a closed system / wall applies external force // the wall moves a little because the ball hits it/an external force changes momentum …3
[the two parts linked but allow the first 3 if the principle of conservation of momentum is stated as an answer or part of an answer]

Question 6(*b*)

What is meant by (i) the frequency **<u>3</u>**
the number of waves per second …3

(ii) the speed of a wave? **<u>3</u>**
$f\lambda$ / rate of change of position of the wave front …3
[omit to explain f, λ (–1)]

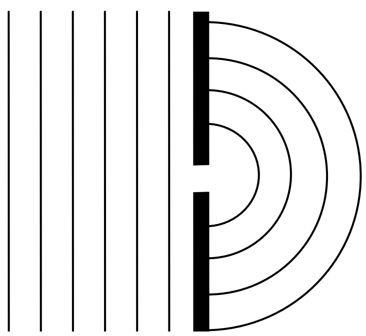
Figure 8 shows a wave of wavelength λ and amplitude *A*.
State the distance marked X in terms of λ and the distance marked Y in terms of *A*. **<u>2×3</u>**
X: 2½λ …3
Y: 2*A* …3
[X: 2½ (–1), Y: 2 (–1)]

Name the phenomenon that occurs when two waves meet. **<u>6</u>**
interference …6

Explain in terms of amplitude what happens when two waves travelling in the same direction meet
(i) in phase **<u>3</u>**
(resultant wave has) double (original amplitude) / increased amplitude …3

(ii) completely out of phase. **<u>3</u>**
(resultant wave has) zero (amplitude) / decreased amplitude …3
[constructive and destructive interference …3]

Plane transverse waves approach a gap in an obstacle as shown in Figure 9. Copy the diagram into your answerbook and show on it what happens as the waves go through the gap and into the space beyond the obstacle. **<u>6</u>**



…6

How does the outcome depend on the relationship between λ and the width of the gap? **<u>3</u>**
the smaller the gap (compared to λ) the more diffraction/the wider the gap (compared to λ) the less diffraction 3

Question 6 (*c*)

To demonstrate the photoelectric effect, a freshly cleaned zinc plate was placed on the cap of a negatively charged gold leaf electroscope and was exposed to different types of electromagnetic radiation.

What is the photoelectric effect? <u>**2×3**</u>

release of electrons from the surface of a metal/ zinc …3

when exposed to (electromagnetic) radiation/ light above a certain frequency/ u.v. light/ light of suitable frequency …3

[u.v. light shines on zinc …3]

What was observed when infrared radiation was used? Justify your answer. <u>**2×3**</u>

nothing / leaves don't collapse / no photoelectric effect …3

frequency (of infrared radiation) too low/ photons (of infrared radiation) do not have enough energy / work function too big / electrons bound too strongly to metal …3

Describe how the electroscope was charged negatively. <u>**2×3**</u>

by induction // attach to dome of negatively charged …3

bring positively charged rod near cap and touch cap with finger // van der Graaf generator …3

Give one application of the photoelectric effect. <u>**3**</u>

security alarms, counting devices, detecting light levels for TV cameras or switches, automatic doors or automatic lights, etc

any one …3

Radiation of wavelength 3.6×10^{-7} m caused the leaves to collapse.

Calculate

(i) the frequency of this radiation <u>**2×3**</u>

$c = f\lambda$ or $f = \dfrac{c}{\lambda}$ …3

$f = \dfrac{3\times10^{8}}{3.6\times10^{-7}} = \mathbf{8.33 \times 10^{14}\ Hz}$ **…3**

[no unit or incorrect unit (–1)]

(ii) the energy of a photon of this radiation. <u>**2×3**</u>

$E = hf$ …3

$E = 6.6 \times 10^{-34} \times 8.33 \times 10^{14} = 5.5 \times 10^{-19}$ J …3

[no unit or incorrect unit (–1)]

Question 6 (*d*)

The radioactive element polonium was discovered in 1898 by Marie Curie. Polonium–209 is its longest-lived isotope and has a half-life of 103 years. It is an alpha particle emitter.

What is an alpha particle? **3**

helium // He // protons and neutrons …3

nucleus / dipositive // $^{4}_{2}$ // two of each …3

How far can alpha particles penetrate air? **3**

a few cm / about 4-5 cm …3

[stopped by a sheet of paper or any other indication of poor penetration (–1)]

Write a nuclear equation to represent the decay of a polonium–209 nucleus when it emits an alpha particle. **4×3**

$$^{209}_{84}\text{Po} \rightarrow \ ^{205}_{82}\text{Pb} + \ ^{4}_{2}\text{He}$$

lead product …3

alpha particle written as $^{4}_{2}$He …3

atomic masses balanced …3

atomic numbers balanced …3

[$^{205}_{82}$Pb …9]

The laboratory notebooks used by Marie Curie in 1898 are still contaminated with her radioactive fingerprints. In what year had the radioactivity due to the polonium–209 in the notebooks reduced to half its original level? **6**

2001 …6

Give two precautions that should be taken to ensure safety when working with radioactive substances. **5, 1**

wear gloves, use tweezers, wear shielding, store in lead boxes, keep samples locked away, use as little as reasonably achievable (ALARA) approach, etc

first correct…5

second correct…1

Question 7

Any eleven parts. **<u>11×3</u>**

(*a*) Identify the ion that has ten electrons and thirteen protons. **<u>2×3</u>**

Aluminium …3

3+ …3

(*b*) What are isotopes?

same atomic number / same number of protons …3

different mass number / different number of neutrons …3

(*c*) Figure 9 shows the structure and bonding in graphite, an allotrope of carbon. What type of bond holds the carbon atoms together (i) within each layer (ii) between adjacent layers? **<u>5, 1</u>**

covalent bonds or aromatic bonding

van der Waals (forces) / intermolecular bonds

first correct…5

second correct…1

(*d*) What is a mole of a substance? **<u>6</u>**

has same number of particles as 12 g carbon-12 / has 6×10^{23} particles or Avogadro number of particles/ same mass as molecular mass in grams /gram molecular mass …6

or

SI unit for …3

amount of substance …3

(*e*) Define the first ionisation energy of a neutral gaseous atom of an element. **<u>2×3</u>**

minimum energy required to remove …3

outermost electron completely / most loosely bound electron completely (from a mole of substance) …3

[minimum omitted (–1), completely omitted (–1)]

(*f*) Distinguish between an *exothermic* reaction and an *endothermic* reaction. **<u>2×3</u>**

exothermic: releases heat /releases energy / gives out heat / gives out energy / temperature rises …3

endothermic: absorbs heat /absorbs energy / takes in heat / takes in energy / temperature falls …3

(*g*) Why does sodium chloride conduct electricity in solution but not in the solid state? **<u>6</u>**

ions free to move in solution / ions not free to move in solid …6

(*h*) In the following reaction, what species acts (i) as the acid, (ii) the conjugate acid? **<u>2×3</u>**

$$HNO_3 + H_2F_2 \rightleftharpoons H_2NO_3^+ + HF_2^-$$

acid: H_2F_2 …3

conjugate acid: $H_2NO_3^+$ …3

(*i*) Give two properties of anhydrous sodium carbonate, Na_2CO_3, that make it suitable for use as a primary standard in acid-base titrations. **<u>2×3</u>**

solid, soluble, stable, pure, can be weighed out accurately, gives a solution of known concentration

any two …2×3

(*j*) Give an example of (i) an acidic oxide, (ii) an amphoteric oxide. **<u>5, 1</u>**

(i) carbon dioxide, sulphur dioxide, nitrogen dioxide, dinitrogen tetroxide
(ii) water, aluminium oxide, zinc oxide

first correct…5
second correct…1

(*k*) Define *heat of combustion*. **<u>2×3</u>**

energy released when one mole of a substance …3
is completely burned / is burned in excess oxygen …3

(*l*) Calculate the percentage nitrogen in sodium azide, NaN_3, a substance that can be used to inflate air bags in cars. **<u>2×3</u>**

(M_r) = 65 …3

$\frac{42}{65} \times 100 = 64.62$ % (64 -65%) …3

(*m*) Write a balanced chemical equation for the combustion of ethyne (C_2H_2) in excess oxygen.

$$C_2H_2 + 2\frac{1}{2}O_2 \rightarrow 2CO_2 + H_2O$$
$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$

substances …3
balanced …3

(*n*) Identify the saturated hydrocarbon depicted in the structure shown in Figure 11. **<u>2×3</u>**

(2-)methyl /C_4H_{10} …3
propane …3

(*o*) Name the organic compounds (i) and (ii) shown in Figure 12. **<u>5, 1</u>**

phenol
propanone or acetone

first correct…5
second correct…1

Question 8

Figure 13 shows the layout of the first thirty-six elements on the Periodic Table of the elements.

(a) Define (i) atomic number **3**
number of protons (in an atom) …3

(ii) mass number **3**
number of protons and neutrons (in an atom) …3

(iii) relative atomic mass. **2×3**
average mass of (the mass numbers of) all the isotopes // mass of atom relative to …3
taking their natural abundances into account // 1/12th carbon-12 isotope …3

(*b*) Explain the following terms used in Bohr's model of the hydrogen atom:
(i) *energy level* **3**
shell / orbit / (discrete amount of) energy of an electron in an atom …3

(ii) *ground state* **3**
energy level occupied by electron before it is supplied with (additional) energy …3

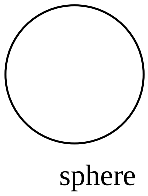
(iii) *excited state.* **3**
higher energy level / energy level occupied by electron after it is supplied with energy …3

What happens when an electron in an excited state in an atom falls to a lower energy state? **6**
light emitted / radiation emitted …6
[coloured lines or $E = hf$ …3]

Describe how you could carry out a flame test on a salt of element 11. **4×3**
dip platinum rod in HCl to clean // soak wooden sticks in water overnight // solution of salt / grains of salt …3
dip rod in salt (of sodium) // dip stick in salt (of sodium) // spray / sprinkle …3
hold rod in Bunsen flame // hold stick in Bunsen flame // in Bunsen flame …3

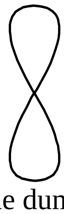
(*c*) Sublevels and atomic orbitals are also important structural features of an atom.
Define the term *atomic orbital*. **2×3**
region in space / around the nucleus …3
where there is a high probability of finding an electron / where an electron is most likely to be found ….3
[area (–1)]

Sketch the shape of (i) the *s* atomic orbital **3**



sphere …3

(ii) the *p* atomic orbital. **3**



one dumbell …3

Give the electron configuration of the element 7 showing the arrangement of the electrons in orbitals. **3**

$1s^2 2s^2 2p_x^{\ 1} 2p_y^{\ 1} 2p_z^{\ 1}$ …3

How many sublevels are occupied by these electrons? **3**

3 …3

What do the electron configurations of elements 21 to 30 have in common? **2×3**

last electron goes into / highest energy electron in // d-sublevel …3

d-subshell // filling …3

Quantum numbers give information about electrons in atoms. What information about an electron is given by (i) the *principal quantum number*, (ii) the subsidiary quantum number? **2×3**

main energy level or shell or orbit (to which electron belongs) …3

type of subshell (to which electron belongs) …3

Question 9

Vinegar is an aqueous solution containing CH_3COOH, a weak acid. A solution of diluted vinegar was titrated against 20.0 cm^3 portions of a 0.12 M standard solution of potassium hydroxide, which is a strong base, using a suitable indicator. One rough and two accurate titrations were carried out.
The following volumes of diluted vinegar were recorded:
22.7 cm^3 22.4 cm^3 22.3 cm^3

The balanced equation for the titration reaction is:

$$CH_3COOH + KOH \rightarrow CH_3COOK + H_2O$$

(*a*) Define (i) a weak acid **2×3**
poor / slightly dissociated …3
proton donor …3

(ii) a strong base, according to Brønsted-Lowry theory. **3**
good proton acceptor …3

What is the conjugate base of CH_3COOH? **3**
CH_3COO^- …3

Is this conjugate base weak or strong? Explain. **3**
conjugate of weak acid must be strong. …3

(*b*) Define pH. **3**
(pH=) $-\log_{(10)}[H^+]$ …3

Calculate the pH of the 0.12 M KOH solution. **2×3**
(pOH =) $-\log_{(10)}[OH^-] = -\log_{(10)}[0.12] = 0.9(2)$ …3
14 – 0.92 = 13.08 (13.08 -13.1) …3

(*c*) Describe the correct procedure for
(i) rinsing a 20 cm^3 pipette for use in this titration **2×3**
rinse with deionised or distilled water …3
then with KOH or solution it is to deliver …3

(ii) filling the pipette to the mark **3**
Use pipette filler / adjust until bottom of meniscus lies on mark / read at eye level …3

(iii) using the pipette to deliver exactly 20.0 cm^3 to a conical flask. **3**
do not blow out or shake out the last drop / wait a few seconds at the end for drainage / touch any drop clinging to outside of pipette tip against wall of conical flask …3

(*d*) What is an acid-base indicator? **6**
substance that changes colour in solutions of different pH …6

Name a suitable indicator for this titration. **3**
phenolphthalein …3

State the colour change in the conical flask at the end point of this titration. **2×3**
purple/pink …3
colourless …3
[clear unacceptable][colours reversed …3]

(*e*) Calculate the concentration of CH_3COOH in the diluted vinegar solution in:

(i) moles per litre **3×3**

22.35 (cm^3) …3

$\frac{V_1 M_1}{n_1} = \frac{V_2 M_2}{n_2}$ / (volume × molarity × proticity)$_1$ = (volume × molarity × proticity)$_2$ …3

$\frac{22.35 \times M_1}{1} = \frac{20 \times 0.12}{1} \Rightarrow M_1$ = 0.107 (M) = [0.10 - 0.11 (M)] …3

(ii) grams per litre. **2×3**

(M_r) = 60 …3

0.107 × 60 = 6.42 (g/l) = [6.0 – 6.6 (g/l)] …3

Question 10

The electrochemical series lists the common metals in order of their decreasing ease of oxidation. Chemical reactions of the metals can often be explained in terms of the metals positions' on the electrochemical series.

(*a*) Place the metals iron, silver, sodium and magnesium in the order they occur in the electrochemical series. **6**

sodium, magnesium, iron, silver …6

[two in correct order or all in reverse order …3]

Explain why everyday objects are rarely made of magnesium and never made of sodium. **3**

too easily oxidised or too reactive or would corrode too easily …3

(*b*) Define in terms of electron transfer (i) *oxidation*, **3**

loss of electrons …3

(ii) *reduction*. **3**

gain of electrons …3

Identify (i) the substance oxidised, **3**

magnesium …3

(ii) the species that behaves as the reducing agent in the following reaction:

$$3Mg + Fe_2O_3 \rightarrow 3MgO + 2Fe$$ **3**

magnesium …3

(*c*) What is observed when small pieces of (i) sodium, (ii) silver are added to cold water? **2×3**

(vigorous) reaction (between sodium and water) …3

no reaction (between silver and water) …3

Write balanced chemical equations for any reactions that occur. **2×3**

$$Na + H_2O \rightarrow NaOH + \tfrac{1}{2}H_2$$

correct products …3

balanced …3

(*d*) Explain why a piece of magnesium ribbon wound closely around an iron key, as shown in Figure 14, protects the key from corrosion. **6**

magnesium above iron (in electrochemical series) / magnesium corrodes in preference to iron / magnesium is a sacrificial anode any one…6

(*e*) A second identical iron key was electroplated with silver to protect it from corrosion using an electrolysis arrangement as shown in Figure 15.

What is electrolysis? **2×3**

chemical change …3

caused by electric current …3

State *Faraday's first law of electrolysis*. **2×3**

mass of element (liberated at electrode during electrolysis) …3

proportional to charge that passes / amount of electricity …3

Write a balanced equations for the reactions at the cathode and anode. **2×3**

$Ag^+ + e^- \rightarrow Ag$ …3

$Ag \rightarrow Ag^+ + e^-$ …3

A current of 1.93 A was passed through the silver nitrate solution for 2.5 minutes.

Calculate (i) the charge that flows, **3**

$Q = It = 1.93 \times 2.5 \times 60 = 289.5$ C …3

[incorrect units / no units (–1)]

(ii) the mass of silver plated on the key. **2×3**

$\frac{289.5}{96485} = 0.003$ (moles electrons) …3

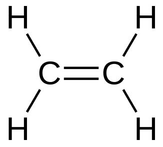
$0.003 \times 108 = 0.324$ (g) …3

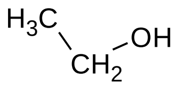
Question 11

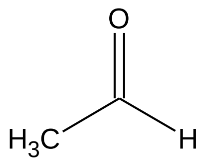
Explain each of the following terms (i) *functional group* **2×3**
atom, group of atoms or type of bond …3
that determines chemical properties (of an organic compound) …3

(ii) *homologous series*. **2×3**
(a series of compounds that) have similar chemical properties / have common method of preparation /show gradation in physical properties / differ by $–CH_2$ any two…2×3

Draw the molecular structures of ethene, ethanol and ethanal. **3×3**



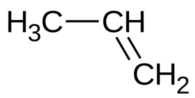




3 3 3

Name the homologous series to which ethene belongs. **3**
alkenes

Name and draw the molecular structure of the next member of this series. **2×3**
propene …3



…3

Describe, with the aid of a labelled diagram, how you could prepare ethene from ethanol. **4×3**
ethanol and aluminium oxide //ethanol and sulfuric acid or H_2SO_4 …3
test tube on side, glasswool to hold ethanol //flask, air condenser …3
heat aluminium oxide with Bunsen // heat flask with Bunsen …3
collect ethene gas over water …3

Describe a test to show that ethene is unsaturated. **3×3**
(add to) bromine solution / (add to) bromine water // acidified potassium permanganate …3
red / brown /yellow // purple …3
changes to colourless / decolourises …3
[clear unacceptable][omit acidified (–1)]

The arrangement shown in Figure 16 was used to prepare ethanal from ethanol by oxidation.
Name the orange coloured reagent A. **3**
sodium dichromate / sodium chromate(VI) / potassium dichromate / $Na_2Cr_2O_7$ / $K_2Cr_2O_7$ …3

Why was the ethanal distilled off as soon as it is formed? **3**
to protect it from further oxidation …3

Why is the collecting flask cooled in ice-water? **3**
to prevent ethanal evaporating / because ethanal is volatile or low boiling …3

A red precipitate formed when a few drops of Fehling's reagent was added to the ethanal product.
What is the purpose of this test? **6**
to confirm aldehyde (functional group) / to show ethanal is a good reducing agent / to show ethanal is easily oxidised …6
[reducing sugar …3]

Question 12

Answer any three parts.

Question 12 (*a*)

Define *electronegativity*. **2×3**
relative attraction / measure of the force of attraction (an atom in a molecule has) …3
for shared pair of electrons / for electrons in a covalent bond …3

Explain the general increase in electronegativity values across a period in the periodic table. **2×3**
(greater attraction for electron pair due to) decreasing atomic radius …3
(greater attraction for electron pair due to) increasing nuclear charge …3

Use electronegativity values to predict the type of bond in the simplest compound of:
(i) magnesium and oxygen **3**
ionic …3

(ii) carbon and hydrogen **3**
pure covalent / non-polar covalent …3
[omit pure or non-polar (–1)]

Which of these two compounds occurs in crystalline form? **2**
magnesium oxide / first one / compound formed between magnesium and oxygen …2

Name the type of crystal formed. **2**
ionic
…2

Question 12 (*b*)

Draw a diagram to show the bonding in a molecule of ammonia. **2×3**
three bond pairs of electrons between nitrogen and three hydrogens …3
one lone pair on N …3

Use the electron pair repulsion theory to explain:
(i) the shape of an ammonia molecule,
(ii) the bond angle in an ammonia molecule. **2×3, 2**
pyramidal …3
107º …3
four bond pairs (around central atom) would be tetrahedral, three lone pairs and one lone pair, lone pair bond pair repulsions stronger than bond pair bond pair repulsions any one …2

Does an ammonia molecule have a dipole moment? Justify your answer. **2×3**
yes / ammonia has a dipole moment …3
centre of positive charge does not coincide with centre of negative charge …3

Account for the difference in shape between an ammonia molecule and a boron trifluoride molecule. **2**
ammonia has a lone pair / four pairs of electrons / boron trifluoride has no lone pairs / three pairs of electrons any one…2

Question 12 (*c*)
Air purifying cartridges containing lithium peroxide Li_2O_2 are used in submarines and in spacecraft to absorb the carbon dioxide produced during respiration and to release oxygen. The reaction that occurs is:

$$2Li_2O_2 + 2CO_2 \rightarrow 2Li_2CO_3 + O_2$$

Calculate

(i) the number of moles of lithium peroxide in a 460 g air purifying cartridge **2×3**
(M_r) = 46 …3
$\frac{460}{46} = 10$ (moles) …3

(ii) the volume of carbon dioxide absorbed by one cartridge, if measured at STP **2×2**
10 (moles) …2
× 22.4 = 224 (litres) or 224 000 (cm^3) …2

(iii) the mass of lithium carbonate waste formed when a cartridge is used up **2×3**
(M_r) = 74 …3
10 × 74 = 740 (g) …3

(iv) the number of molecules of oxygen released when one cartridge is used up. **2×3**
5 (moles) …3
$5 \times (6 \times 10^{23}) = 3 \times 10^{24}$ …3

Question 12 (*d*)
State *Hess's law.* **2×3**
heat change for a reaction …3
independent of path taken / depends only on initial and final states …3

The balanced equation for the preparation of ethyne is:

$$CaC_{2\,(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2\,(g)} + Ca(OH)_{2\,(s)}$$

Use Hess's law and the heats of formation listed to calculate the heat produced in the preparation of ethyne.

$2C_{(s)} + H_{2\,(g)}$	$\rightarrow$	$C_2H_{2\,(g)}$	ΔH =	227 kJ mol^{-1}
$H_{2\,(g)} + ½O_{2\,(l)}$	$\rightarrow$	$H_2O_{(g)}$	ΔH =	– 286 kJ mol^{-1}
$Ca_{(s)} + 2C_{(s)}$	$\rightarrow$	$CaC_{2\,(s)}$	ΔH =	– 60 kJ mol^{-1}
$Ca_{(s)} + H_{2\,(g)} + O_{2\,(g)}$	$\rightarrow$	$Ca_2(OH)_{2\,(s)}$	ΔH =	– 985 kJ mol^{-1}

2×3. 3×2

($CaC_{2\,(s)} \rightarrow Ca_{(s)} + 2C_{(s)}$	ΔH =)	60 (kJ mol^{-1})	…3
($2H_2O_{(g)} \rightarrow 2H_{2\,(g)} + O_{2\,(l)}$	ΔH =)	572 (kJ mol^{-1})	…3
($2C_{(s)} + H_{2\,(g)} \rightarrow C_2H_{2\,(g)}$	ΔH =)	227 (kJ mol^{-1})	…2
($Ca_{(s)} + H_{2\,(g)} + O_{2\,(g)} \rightarrow Ca_2(OH)_{2\,(s)}$	ΔH =)	– 985 (kJ mol^{-1})	…2
($CaC_{2\,(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2\,(g)} + Ca(OH)_{2\,(s)}$	ΔH =)	–126 (kJ mol^{-1})	…2

[= 126 (kJ mol^{-1}) (–2)]

Ethyne gas is prepared in a school laboratory by adding water to solid calcium carbide and collecting the gas produced over water, as shown in Figure 17.
Does the temperature inside the reaction flask increase or decrease as the reaction proceeds? Justify your answer. **2×2**
increases …2
exothermic / heat released /ΔH negative …2