Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2023

Marking Scheme

Physics and Chemistry

Ordinary Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

General Guidelines

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

1. In many instances only key words are given, i.e. 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 from a relevant diagram, depending on the context.

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

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

8. Cancellation may apply when a candidate gives a list of correct and incorrect answers.

9. 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.

10. Bonus marks at the rate of 10% of the marks obtained will be given to a candidate who answers entirely through Irish and who obtains less than 75% of the total marks. In calculating the bonus to be applied decimals are always rounded down, not up, e.g. 4.5 becomes 4; 4.9 becomes 4, etc.
The bonus table given on the next page applies to candidates who answer entirely through Irish and who obtained more than 75% of the total marks.

Coimisiún na Scrúduithe Stáit

400@10%

Marcanna Breise as ucht freagairt trí Ghaeilge

Léiríonn an tábla thíos an méid marcanna breise ba chóir a bhronnadh ar iarrthóirí a ghnóthaíonn níos mó ná 75% d'iomlán na marcanna.

N.B. Ba chóir marcanna de réir an ghnáthráta a bhronnadh ar iarrthóirí nach ngnóthaíonn níos mó ná 75% d'iomlán na marcanna don scrúdú. Ba chóir freisin an marc bónais sin **a shlánú síos**.

Tábla 400 @ 10%

Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 400 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.

Bain úsáid as an ngnáthráta i gcás 300 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	Marc Bónais
301 - 303	29
304 - 306	28
307 - 310	27
311 - 313	26
314 - 316	25
317 - 320	24
321 - 323	23
324 - 326	22
327 - 330	21
331 - 333	20
334 - 336	19
337 - 340	18
341 - 343	17
344 - 346	16
347 - 350	15

Bunmharc	Marc Bónais
351 - 353	14
354 - 356	13
357 - 360	12
361 - 363	11
364 - 366	10
367 - 370	9
371 - 373	8
374 - 376	7
377 - 380	6
381 - 383	5
384 - 386	4
387 - 390	3
391 - 393	2
394 - 396	1
397 - 400	0

Question 1
Any eleven parts **11×6**

(*a*) Figure 1 shows a tennis ball. During a game a tennis ball was served by a player at 140 km per hour. What was the speed of the ball in m s^{-1}? **4, 2**
140,000 (m per hour) / 2.333 (km per minute) / 0.0388 (km per second) …4
38.8 or 38.9 (m per second) …2

(*b*) A table is pushed 2.5 m along a floor by a force of 20 newtons. Calculate the work done. **4, 2**
(*W* =) *F* × *s* / (*W* =) 20 × 2.5
= 50 (J) first correct …4, second …2

(*c*) What is the displacement of A from B in Figure 2? **4, 2**
5 m
north / above / up first correct …4, second …2

(*d*) State Newton's third law of motion. **4, 2**
for every action or force …4
there is an equal and opposite reaction or force / there is an equal reaction or force in opposite direction…2

(*e*) What is the thermometric property associated with a liquid-in-glass thermometer? **6**
volume (allow 'amount') or height or length or expansion (of liquid) ...6

(*f*) A room thermostat is set at 19 °C. What is this temperature on the Kelvin scale? **6**
19 + 273(.15) = 292(.15) (K) ...6
[reference to 273(.15) without further work …4]

(*g*) How could you demonstrate dispersion of white light? **6**
prism / diffraction grating / rainbow / oil on water / spectrum, etc. …6

(*h*) What term describes what happens when two waves with the same wavelength meet? **6**
(constructive or destructive) interference / they add / they cancel ...6

(*i*) Figure 3 shows light passing through a glass lens. What type of lens is shown? **6**
(bi)concave or diverging …6

(*j*) Light from a laser is described as monochromatic. Explain the underlined term. **6**
one wavelength or one colour or one frequency …6

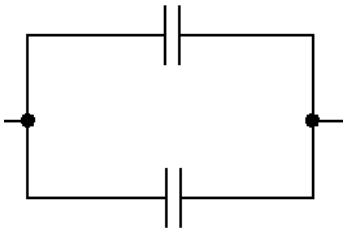
(*k*) Give an example of a longitudinal wave. **6**
sound / ultrasound / 'Slinky' / spring / pressure / seismic (waves) or P-waves / explosions, etc. …6

(*l*) Define capacitance. **4, 2**
[1]ratio of charge or *Q* // [2]amount of charge that can be stored // [3]*Q* ÷ …4
[1]to potential difference or voltage or *V* // [2]at a given voltage (by a capacitor) // [3]*V* …2

(*m*) Sketch a diagram to show two capacitors connected in parallel. **4, 2**

correct circuit symbol used for capacitor …4

parallel connection of two capacitors …2



(*n*) Figure 4 shows a 150 kW electric vehicle high power charge point. How long will it take this charger to deliver 75 kW h of energy? **4, 2**

$P = \frac{E}{t}$ / $150 = \frac{75}{t}$ / $t = 75 \div 150$

(t =) 0.5 (hours) or 30 (minutes) first correct …4, second …2

(*o*) What is the purpose of a fuse in a three-pin plug? **6**

safety / to melt or blow (if certain current is exceeded) / to protect (the circuit) / to prevent (electrical) overload …6

(*p*) Copy and complete the following statement:

"A wire carrying a . . . . . in a magnetic field experiences a . . . . . ." **4, 2**

current or charge

force / push / pull / movement first correct …4, second …2

(*q*) The charge on an electron is –1. What is the charge on an alpha-particle? **6**

+2 …6

[allow '+' for …3] [allow '–2' for …3]

(*r*) What type of nuclear reaction produces heat energy in the core of the sun? **6**

fusion …6

Question 2

(*a*) Define

(i) mass, **6**

quantity of matter (in an object) / measure of a body's inertia / measure of a body's ability to resist acceleration / $m = \frac{W}{g}$ …6

(ii) force. **6**

push or pull / interaction between two objects /
causes (or tends to cause) acceleration or change of direction or change of shape / $m \times a$ …6
[allow a correct example of a force for …3]

(iii) State the SI unit of mass **6**

kilogram / kg …6
[allow 'grams' or 'g' for …3]

(*b*) Figure 5 shows a tractor ploughing in a field. The velocity of the tractor increased steadily from zero to 6 m s^{-1} in 8 s.
Calculate

(i) the acceleration of the tractor **4, 2**

$a = \frac{v-u}{t}$ / $v = u + at$ / $a = \frac{6-0}{8}$

0.75 m s^{-2} first correct …4, second …2
[no unit or incorrect unit (–1)]

(ii) the distance travelled by the tractor in the 8 seconds. **6, 3**

$s = ut + ½at^2$ / $s = ½at^2$ / s = ½ × 0.75 × 8^2 //
$s = ½(u + v)\,t$ / $s = ½(0 + 6) \times 8$ //
$v^2 = u^2 + 2as$ / $6^2 = 0^2 + 2(0.75)s$ //
(⇒ s =) 24 m first correct …6, second …3
[no unit or incorrect unit (–1)]

A force of 5,025 N applied by the tractor engine caused this acceleration. Calculate

(iii) the mass of the tractor **4, 2**

$F = ma$ / 5025 = m(0.75)
(⇒ m =) 6700 kg first correct …4, second …2
[no unit or incorrect unit (–1)]

(iv) the kinetic energy of the tractor when its speed was 6 m s^{-1}. **4, 2**

(E_K =) $½mv^2$ / (E_K =) ½(6700)6^2
(⇒ E_K =) 120600 J first correct …4, second …2
[no unit or incorrect unit (–1)]

(*c*) (i) Draw a diagram of an arrangement of apparatus, e.g. pendulum, free-fall method, etc., you could use in an experiment to measure the acceleration due to gravity, *g*. **2×3**

pendulum:
bob …3
suspended by string …3
or or
freefall apparatus:
ball (held by electromagnet) …3
trapdoor or start-stop timing circuit …3
or or
freely falling object:
timer …3
object falling through defined drop …3
[no diagram max …3]

(ii) What two measurements are taken in the experiment? **4, 2**

pendulum:
time (for bob to complete a number of oscillations) …4
length of string …2
or or
freefall apparatus:
time (for fall from electromagnet to trapdoor) …4
length of drop …2
or or
freely falling object:
time (for object to fall from rest) …4
length of drop …2

(iii) How was a value for *g* obtained from the measurements taken? **3**

pendulum:
find *g* from formula $T = 2\pi\sqrt{\frac{l}{g}}$ or $T^2 = 4\pi^2\frac{l}{g}$ or find *g* from slope of graph of *T* versus $\sqrt{l}$ or T^2 versus l …3
or or
free fall apparatus or freely falling object:
find *g* using formula $s = \frac{1}{2}gt^2$ or find *g* from slope of graph of *s* versus t^2 …3

(iv) Give one precaution to ensure an accurate result. **6**

ensure no draughts (disturb the set-up) //
pendulum: average time (for several oscillations) / repeat (for different lengths of string) / use long string / measure length to centre of bob / clamp with split cork, etc. //
free fall apparatus: minimum time (for several falls of same length) / repeat (for different lengths of fall) / use long fall / measure drop from bottom of ball to top of trapdoor / paper between ball and electromagnet, etc. [average time for several falls for this method …3] //
freely falling object: repeat (to get average time or minimum time for several falls of same length) / repeat (with different defined drop lengths) / use electronic start-stop and not manual start-stop system, etc.
any one…6

Question 3

(*a*) Figure 6 shows a mirror ball made of small plane mirrors attached to a spherical structure which rotates while illuminated with a beam of light.

(i) Explain the underlined term. **4, 2**

flat …4

reflecting (surface(s)) …2

Light is reflected by the mirror ball.

(ii) State the laws of reflection of light. **4, 2, 6**

angle of incidence equal to …4

angle of reflection …2

and *and*

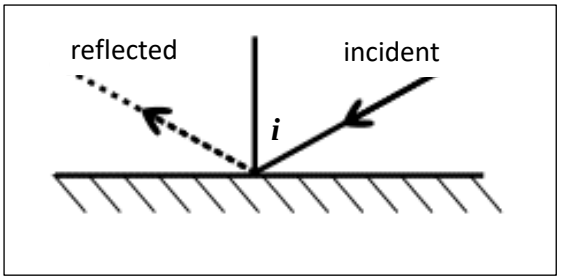
the incident ray or beam, the reflected ray or beam, and the normal, all in the same plane …6

[allow '*i* = R' for …3]

['normal' omitted (–1)] [reference to only two of: incident ray, reflected ray, normal (–1)]

['refraction' instead of 'reflection' (–3) but once only for both laws]

(iii) Draw a labelled diagram of one of the small plane mirrors from the mirror ball showing a ray of light striking it at an angle of incidence *i* and being reflected. **3×3**



incident ray and reflected ray drawn and either one labelled with name or arrowhead …3

angle between normal and incident ray labelled angle of incidence or *i* …3

angle of incidence = angle of reflection …3

(iv) State the value of the angle of reflection in the plane mirror when a ray strikes a plane mirror at an angle of incidence of 65°. **3**

65° …3

(*b*) A concave mirror is one type of curved mirror.

(i) Name another type of curved mirror. **6**

convex …6

Figure 7 shows a pin at a distance of 12 cm from a concave mirror of focal length 6 cm.

(ii) Copy and complete the diagram to show how the two rays are reflected by the mirror and form an image of the head of the pin. **2×6**

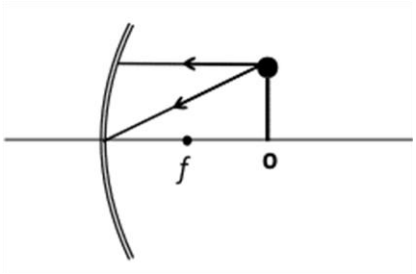


Figure 7

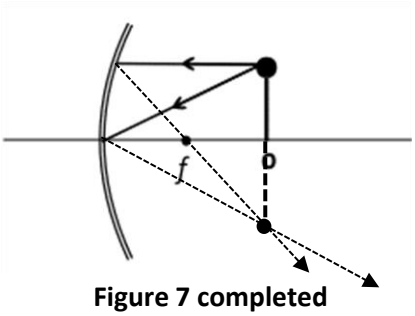


Figure 7 completed

any two reflected rays correctly drawn …2×6

(iii) Explain the term *real image*. **6**

formed by intersection of light rays / can be formed on a screen / formed in front of mirror …6

[allow 'inverted' for …3]

Consider the images of two identical pins, one placed 12 cm in front of a plane mirror, and the other placed 12 cm in front of a concave mirror of focal length 6 cm.

State **9, 3**

(iv) one similarity, and

(images are the) same size or (images are) neither magnified nor diminished or (images are) same size as object / image distances from mirror equal, etc.

(v) one difference, between the two images.

one upright or one inverted / one real or one virtual or imaginary / one formed behind mirror or one formed in front of mirror, etc.

first correct …9, second …3

Question 4

(*a*) The kinetic theory of gases makes a number of assumptions about the behaviour of the particles of a gas.

(i) State two of these assumptions. **2×3**

(large number of) particles or molecules / rapid motion / random motion / straight line motion / collisions occur (between particles or molecules) / collisions occur with walls of container / collisions elastic or involve neither loss nor gain of energy / negligible volume occupied by particles or molecules / negligible duration of collisions / no forces (between particles except during collisions), etc. any two **…**2×3

(ii) Name the scientist who first described molecular agitation based on his observation of the behaviour of pollen grains in water. **3**

Brown …3

(iii) Which property of a gas, temperature or pressure or volume, is determined by the average kinetic energy of the particles? **3**

temperature …3

(iv) The following words are used in the statement of Charles' law of gases:

proportional volume temperature pressure

Using these words, copy and complete Charles' law:

'The …… of a fixed mass of gas is …… to the absolute …… at constant ……' **4×6**

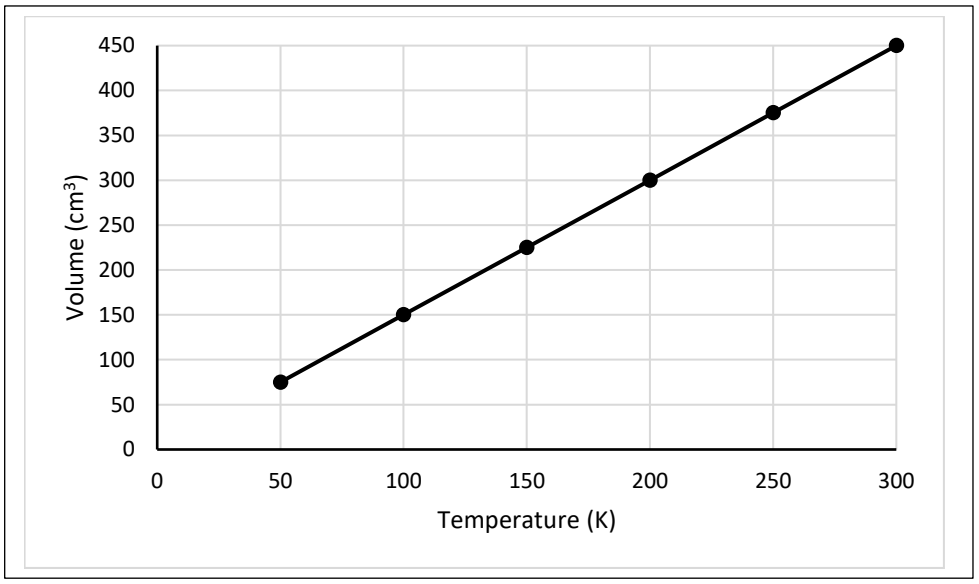
'The volume of a fixed mass of gas is proportional to the absolute temperature at constant pressure.' …4×6

(*b*) The data in the table were recorded in an experiment to investigate Charles' law for a fixed mass of a gas.

Volume (cm^3)	75	150	225	300	375	450
Temperature (K)	50	100	150	200	250	300

(i) Draw a graph on graph paper of volume (*y*-axis) against temperature (*x*-axis). **4×3**

x-axis labelled temperature or *T* or K *and* *y*-axis labelled volume or *V* or cm^3 …3
axes drawn with appropriate scales …3
six points plotted correctly …3
points joined by a straight line …3
[allow …9 max if graph paper not used]
[if axes reversed (−1)]



(ii) Does your graph verify Charles' law? Justify your answer. **6, 3**

yes …6
straight line …3

(iii) Use your graph to estimate the volume of the gas sample at 80 K. **6**

120 (cm^3) …6

(iv) No experimental data could be obtained for the gas at a temperature of 0 K. Suggest a reason for this. **3**

absolute zero or 0 K is theoretical / absolute zero or 0 K cannot be reached / gas liquefies above 0 K …3

Question 5

(*a*) Heating is one effect of an electrical current in a circuit. Figure 8 shows a problem caused by excessive heating in an electrical circuit.

(i) State two other effects of a current in a circuit. **4, 2**

chemical

magnetic — first correct …4, second …2

(ii) Distinguish between *direct* and *alternating* current. **9, 3**

direct: flows in one direction only

alternating: reverses (allow 'changes') direction (periodically) — first correct …9, second …3

Identify the type of current, direct or alternating, supplied

(iii) by a battery, **6**

direct …6

(iv) by a mains electricity socket. **6**

alternating …6

(*b*) (i) What term describes the arrangement of the two resistors in the circuit shown in Figure 9? **6**

series …6

Calculate

(ii) the effective resistance of this combination of resistors **4, 2**

$R = R_1 + R_2$ / R = 100 + 200 …4

(⇒ R =) 300 (Ω) …2

[calculation for parallel here instead of for series …3 max]

(iii) the current in the circuit **4, 2**

$V = IR$ / $I = \frac{V}{R}$ / I = 12 ÷ 300 …4

(⇒ I =) 0.04 A …2

[no unit or incorrect unit (–1)]

(iv) the voltage (potential difference) across the 100 Ω resistor. **4, 2**

$V = IR$ / V = 0.04 × 100 …4

(⇒ V =) 4 V …2

(*c*) The car headlamp bulb shown in Figure 10 has a power rating of 55 W.

(i) What is the current when the bulb is connected to a 12 V supply? **4, 2**

$P = VI$ / $I = \frac{P}{V}$ / I = 55 ÷ 12 …4

(⇒ I =) 4.58 – 4.6 A …2

[no unit or incorrect unit (–1)]

(ii) What could happen if the current in the filament of the bulb were to exceed this value? **6**

(filament could glow) brighter / bulb or filament could blow or fail / filament could melt / overheating / fire, etc. …6

Question 6
Answer any two of the parts (a), (b), (c) (d). **2×33**

(*a*) (i) What is meant by the *momentum* of an object? **2×3**
[1]product of mass // [2]*m* × ...3
[1]and velocity // [2]*v* ...3

(ii) Give the SI unit for momentum. **6**
kg m s^{-1} …6

Figure 11a shows trolley A held against spring-loaded trolley B on a smooth level bench. Both trolleys were initially at rest. Trolley A had a mass of 1.5 kg and spring-loaded trolley B had a mass of 3.0 kg. When the spring was released, trolley A moved to the left at a speed of 2.8 m s^{-1} while trolley B and its spring moved to the right at a speed of 1.4 m s^{-1}, as shown in Figure 11b.

(iii) What was the total momentum of the trolleys before the spring was released? **6**
zero / 0 …6

(iv) Calculate the momentum of trolley A *after* the spring was released. **4, 2**
mv / –2.8 × 1.5 …4
(*mv* =) –4.2 (kg m s^{-1}) or 4.2 (kg m s^{-1}) to the left …2
[negative sign or direction omitted (–1)]

(v) Use the figures given above to determine whether the principle of conservation of momentum applied. **6, 2, 1**
mv / 1.4 × 3.0 …6
(*mv* =) 4.2 (kg m s^{-1}) to the right …2
[direction omitted (–1)]
total momentum is still zero / momentum of B to the right cancels momentum of A to the left /
$m_A u_A + m_B u_B = m_A v_A + m_B v_B$ / –4.2 + 4.2 = 0 (kg m s^{-1}) …1

(*b*) Figure 12 shows the main parts of a transformer.

(i) What is the purpose of a transformer? **6**

changes (size of an ac) voltage / transfers electrical energy (allow 'electricity') from one circuit to another …6

(ii) Give an example of a device in the home which uses a transformer. **6**

power supply or charger for a phone or a laptop or a computer / doorbell / loudspeakers / tv, etc. …6

(iii) Identify the parts labelled A, B and C. **3×3**

A: primary coil …3

B: core …3

C: secondary coil …3

A has 9,800 turns and is connected to a 1,000 V supply.

(iv) How many turns has C when the output voltage is 230 V? **6**

$\left(\frac{V_{in}}{V_{out}} = \frac{N_{in}}{N_{out}} / \frac{1000}{230} = \frac{9800}{N_{out}} / \frac{230 \times 9800}{1000}\right)$

($\Rightarrow N_{out}$ =) 2254 …6

Transformers are used in the supply of electrical power from a generating station to individual households and businesses in a distant town.

(v) Why are high voltages used to transmit electrical power over long distances? **6**

smaller current / less heat loss / safety / efficiency …6

[allow e.g. 'loss of electricity' or 'loss of power' for …3]

(*c*) During the radioactive decay of a sodium–24 nucleus one beta particle and two gamma rays are emitted.

(i) Define radioactivity. **4, 2**

(spontaneous) decay of (unstable) nucleus or nuclei

with the emission of radiation / with the emission of alpha, beta, or gamma rays

first correct …4, second …2

[decay of atom(s) (–1)]

Which type of radiation from the decay of sodium–24

(ii) is blocked by 5 mm of aluminium **6**

beta …6

(iii) is unaffected by a magnetic field? **6**

gamma …6

The half-life of sodium–24 is 15 hours.

(iv) Explain the underlined term. **4, 2**

time taken …4

for half a (radioactive) sample to decay / time taken for activity to decrease by half …2

[allow $t_{½} = \frac{0.693}{\lambda}$ for …2]

(v) What fraction of a given sample of sodium–24 remains after 45 hours? **6, 3**

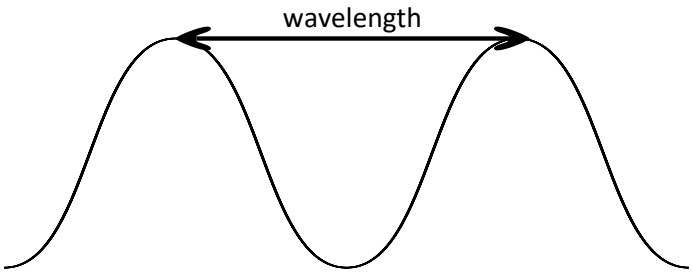
(45 hours =) 3 half-lives …6

(½ left after one half-life $\Rightarrow$ ¼ left after two half-lives $\Rightarrow$) **⅛** (left after three half-lives) …3

(*d*) Five radiations that are part of the electromagnetic spectrum are listed in order of increasing wavelength as follows:

x-rays radiation A visible light radiation B microwaves

(i) Draw a diagram to explain the term *wavelength*. **2×6**



wave drawn …6
wavelength marked …6

(ii) Give one property common to all radiations of the electromagnetic spectrum. **6**
speed / oscillating electrical or magnetic fields …6

The photoelectric effect was demonstrated using the arrangement shown in Figure 13.
The results of the demonstration are given in the table below:

Electromagnetic radiation	Photoelectric effect
x-rays	occurs
radiation A	occurs
visible light	does not occur
radiation B	does not occur
microwaves	does not occur

(iii) Which subatomic particle is emitted during the photoelectric effect? **6**
electron …6

(iv) What is observed in this demonstration when the photoelectric effect occurs? **3**
leaves (of electroscope) collapse or come together …3

(v) Identify radiation A and radiation B. **2×3**
A = ultraviolet (radiation) / uv …3
B = infrared (radiation) / ir …3
[reversed …3]

Question 7

Any eleven parts **11×6**

(*a*) Identify two other elements from the same group in the periodic table as argon (Ar). **4, 2**
helium or He, neon or Ne, krypton or Kr, xenon or Xe, radon or Rn any two …4, 2

(*b*) Define electronegativity. **2×3**
(relative) attraction / (measure of) power of attraction or (measure of) force of attraction …3
for electrons in a shared pair or in a covalent bond …3

(*c*) Figure 14 represents an *s*-orbital.
What is the maximum number of electrons in an *s*-orbital? **6**
2 …6

(*d*) What type of bonding is present in the lattice structure of sodium chloride (NaCl)? **6**
ionic …6

(*e*) What type of bond exists *between* the molecules in water? **6**
hydrogen or H (bond) / intermolecular (force) / dipole-dipole (interaction) …6
[allow van der Waals (force)]

(*f*) What property of a molecule does the *electron pair repulsion theory* predict? **6**
shape …6
[allow 'bond angle' for …6]
[allow 'number of lone pairs' or 'number of bond pairs' for ...3]

(*g*) Identify two transition metals from the following list:
magnesium manganese neon nickel nitrogen **4, 2**
manganese or Mn
nickel or Ni first correct …4, second …2

(*h*) Calculate the percentage by mass of oxygen in titanium dioxide (TiO_2).
[O = 16; T = 48] **4, 2**
(M_r = (48 + (16 × 2) =) 80 ...4
$\frac{32}{80} \times 100 \ / = 40(\%)$ …2

(*i*) Figure 15 shows graphite sticks used by artists. Graphite is an allotrope of the element carbon.
Name another allotrope of carbon **6**
coal / diamond / soot / lamp-black / fullerenes / buckyballs / graphene, etc. …6

(*j*) Define the heat of combustion of hydrogen. **2×3**
(heat change) when one mole of hydrogen (or of a substance) ...3
burns completely or burns in excess oxygen …3
['one mole' omitted (–1)

(*k*) Which gas is produced in the greater volume during the electrolysis of acidified water? **6**
hydrogen or H_2 …6

(*l*) Copy, complete and balance the following equation for the combustion of ethyne in oxygen:

C_2H_2 + O_2 → ____ + ____ **2×3**

$C_2H_2 + 2½O_2 \rightarrow 2CO_2 + H_2O$

correct products …3

balanced …3

(*m*) Starting with the most active, list the following elements in order of *decreasing* chemical activity:

copper calcium potassium iron **6**

potassium, calcium, iron, copper …6

[potassium first, copper last …3]

[reversed …3]

(*n*) What is the product when sulfur reacts with hydrogen gas? **6**

hydrogen sulfide or dihydrogen sulfide / H_2S …6

(*o*) Identify the alcohol oxidised to give ethanal. **6**

ethanol / C_2H_5OH …6

(*p*) Identify the aromatic molecule represented in Figure 16. **6**

benzene …6

Figure 16

(*q*) Select two compounds which contain the hydroxyl group from the following list:

butane ethanol ethene methane phenol **4, 2**

ethanol

phenol first correct …4, second …2

(*r*) Give an example of a chemical classified as a ketone. **6**

propanone / acetone / CH_3COCH_3 / butanone / nail varnish remover, etc. …6

Question 8

(*a*) The table below refers to the two naturally occurring isotopes of the element boron (B).

Element	Atomic number	Mass number	Isotope abundance (%)
B	5	10	20
B	5	11	80

(i) What is meant by the atomic number of an atom of an element? **9**

number of protons / number of electrons in neutral atom [if 'in a neutral atom' omitted …3] …9

(ii) What two types of subatomic particle determine the mass number of a boron atom? **6, 3**

protons

neutrons first correct …6, second …3

(iii) Use the information in the table above to calculate the relative atomic mass of boron. **2×3**

(20 × 10 =) 200 or (80 × 11 =) 880 …3

(200 + 880 =) 1080 or (1080 ÷ 100 =) 10.8 …3

(iv) Write the electron configuration (*s*, *p*) for an atom of boron. **6, 3**

$1s^2$ / [He] …6

$2s^2 2p^1$ / $2s^2\ 2p_x^1$ …3

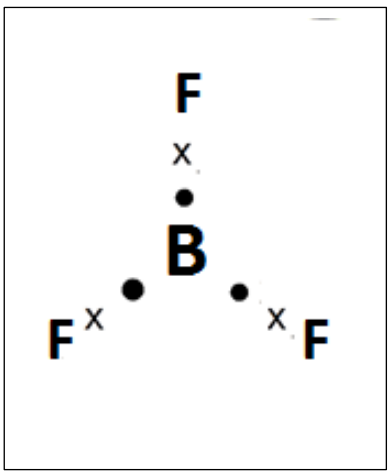
[allow '2, 3' for …5]

(*b*) Boron reacts with fluorine to form the compound boron trifluoride (BF_3).
The boiling points of boron trifluoride and water are given in the table:

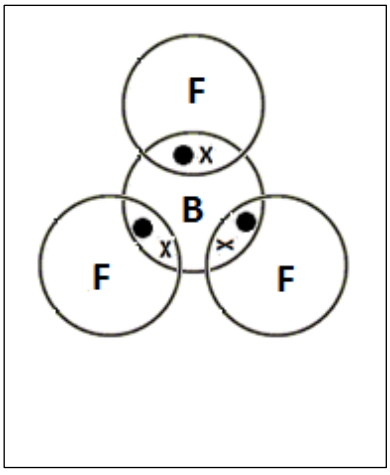
Compound	Boiling point (°C)	Overall dipole moment
BF_3	–100	no
H_2O	100	yes

(i) Sketch a diagram to show the arrangement of atoms in a BF_3 molecule. **6**

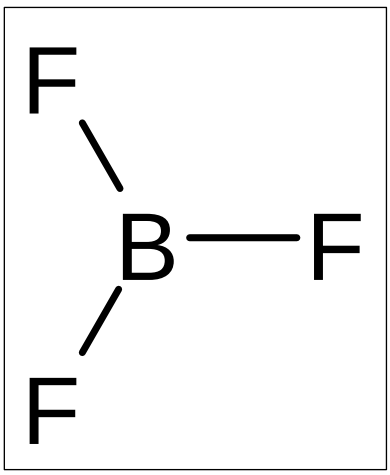
diagram showing three Fs bonded to one B …6



or



or



State

(ii) the shape, **3**

trigonal (planar) …3

[allow 'triangular (planar)' for …3]

(iii) the bond angle, in a BF_3 molecule. **6**

120 (°) …6

(iv) What change of state occurs at the boiling point of a substance? **2×3**

[1]liquid to // [2]gas or vapour to …3

[1]gas or vapour // [2]liquid …3

(v) State the temperature difference between the two boiling points in the table. **6**

200 (°C) …6

(vi) Explain why water has the higher boiling point. **6**

water is polar or boron trifluoride is non-polar /
water has strong intermolecular forces or strong van der Waals forces or H-bonds or dipole-dipole interactions / boron trifluoride has weak intermolecular forces or London or dispersion forces or van der Waals forces /
water has a dipole moment or BF_3 has no dipole moment …6

Question 9

(*a*) (i) Use the Brønsted-Lowry theory to distinguish between an acid and a base. **4×6**

acid:

proton / H^+ …6

donor …6

[allow 'produces hydrogen or H^+ or hydronium or H_3O^+ (in solution)' for …6]

base:

proton / H^+ …6

acceptor …6

[allow 'produces hydroxide ions or OH^- (in solution)' for …6]

(ii) Identify two acids in the following equation:

$HCl + H_2O \rightleftharpoons Cl^- + H_3O^+$ **2, 1**

HCl

H_3O^+ first correct …2, second …1

(iii) What is meant by an acid-base conjugate pair? **3**

(two substances or species that) differ by a proton …3

(iv) Give one example of an acid-base conjugate pair in the equation above. **3**

HCl and Cl^- or H_2O and H_3O^+ …3

(v) Acids dissociate in water. What term describes an acid that is not fully dissociated in water? **3**

weak …3

(*b*) (i) Define the pH of a solution. **6**

$pH = -\log[H^+]$ …6

(ii) Calculate the pH of a 0.014 M nitric acid (HNO_3) solution. **6, 3**

(pH =) –log[0.014] …6

(pH =) 1.85 or 1.9 ...3

(iii) What is the pH value of a neutral solution? **6**

7 …6

Adding carbon dioxide gas to mineral water changes it from still to sparkling. See Figure 17.

(iv) Is carbon dioxide an acidic, a basic or a neutral oxide? **3**

acidic …3

(v) Does the addition of carbon dioxide to a water supply increase or decrease its pH? **3**

decrease …3

Give a reason for your answer. **3**

acid lowers pH / acids have pH lower than 7 …3

Question 10

A titration was carried out to find the concentration of a solution of potassium hydroxide (KOH). Some pieces of apparatus required to carry out the titration are shown in Figure 18. A was filled with a standard solution of hydrochloric acid (HCl). The HCl was added to 25.0 cm³ portions of the KOH in a conical flask. The KOH was measured out using B.

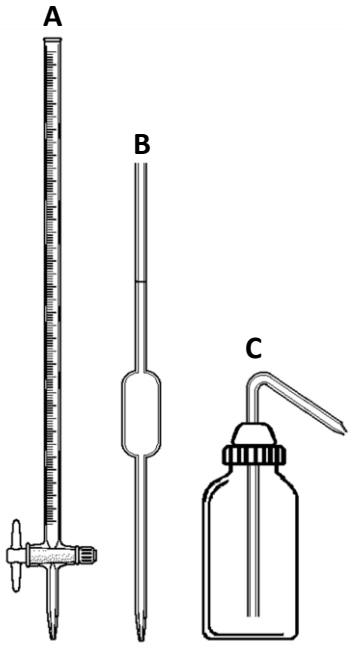


Figure 18

(*a*) (i) Define the underlined term above. **3**

(solution of) known concentration …3

(ii) Identify pieces of apparatus A, B and C. **3×3**

A: burette …3

B: pipette …3

C: wash-bottle …3

[take order of question unless answers clearly labelled]

(iii) Give two uses of C during the experiment. **6, 3**

rinse pipette / rinse burette / rinse conical flask /
wash down sides of conical flask (during titration)

first correct…6, second …3

(iv) How was A rinsed before filling it with the HCl? **6, 3**

with (deionised or distilled) water …6

then with HCl or hydrochloric acid (solution) or solution it will contain …3

[reversed …3]

(*b*) (i) Why was an indicator added to the KOH solution in the conical flask before adding the HCl? **6**

to identify the end point or neutralisation point / to identify when sufficient acid added to neutralise or react with (all) the KOH or base / colour change …6

It was found that 13.4 cm³ of a 0.12 M solution of HCl neutralised 25.0 cm³ of the KOH solution.
The balanced equation for the titration reaction is:

HCl + KOH → KCl + H_2O

(ii) Calculate the concentration of the KOH solution. **6, 3**

$\frac{V_1M_1}{n_1} = \frac{V_2M_2}{n_2}$ / $\frac{13.4 \times 0.12}{1} = \frac{25.0 \times M_2}{1}$ …6

(M_2 =) 0.06432 or 0.06 (mole/l KOH) …3

[correct formula, incorrect substitution …6 max]

or or

moles of HCl used = $\frac{13.4 \times 0.12}{1000}$ / (moles HCl used) = 0.001608 …6

(0.001608 moles of KOH in 25.0 cm³ $\Rightarrow \frac{0.001608 \times 1000}{25.0}$ =) 0.06432 or 0.06 (mole/l KOH) …3

[correct formula, incorrect substitution …6 max]

(iii) How could the accuracy of this titration experiment be improved? **9**

white tile under conical flask
repeat (procedure)
until titrations agree (to within 0.1 cm^3)
average the results any one …9

(iv) Why should eye protection be worn throughout this experiment? **6**

acids and bases (and indicator) are corrosive or are harmful (to eyes) …6

Question 11

Figure 19 shows a tanker used to transport liquefied natural gas (LNG). Natural gas is mostly methane along with small quantities of ethane, propane and butane. These substances are all hydrocarbons.

(*a*) (i) State one use for methane. **6**

fuel / for cooking or heating or transport / generating electricity / air conditioning, etc. …6

(ii) Suggest an advantage of transporting or storing natural gas in its liquid state. **6**

takes up less space / pipeline not needed / easier to transport, etc. …6

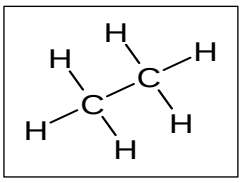
(iii) What are hydrocarbons? **6**

(compounds of) carbon or C and hydrogen or H (only) …6

(iv) Name the homologous series which includes methane, ethane, propane and butane. **6**

alkanes …6

(v) Draw the structure of an ethane molecule showing all of its atoms and all of its bonds. **2×3**



all atoms …3
all bonds …3

(vi) Explain why ethane is described a *saturated* hydrocarbon. **3**

contains no double (or triple) bond or contains no multiple (carbon-carbon) bond / cannot add hydrogen / has only single (carbon-carbon) bonds …3

(vii) Name an unsaturated hydrocarbon with two carbon atoms. **6**

ethene or ethyne …6

(*b*) Methane gas can be converted to hydrogen according to the following balanced equation:

$CH_4 + H_2O \rightleftharpoons 3H_2 + CO$ $\Delta H = +206$ kJ mol^{-1}

(i) Is this an exothermic or an endothermic reaction? **6**

endothermic …6

Give a reason for your answer. **3**

Δ*H* positive / takes in heat …3

When 15 moles of methane react completely according to the equation above, calculate

(ii) the heat change involved, **4, 2**

206 × 15 …4

= 3090 (kJ) …2

(iii) the number of moles of hydrogen gas produced. **4, 2**

3 × 15 …4

= 45 (moles H_2) …2

(iv) How many moles of methane react when the heat change is 4,120 kJ? **4, 2**

4120 ÷ 206 …4

= 20 (moles methane) …2

Question 12
Answer any two of parts (a), (b), (c). **2×33**

(*a*) Hydrogen peroxide (H_2O_2) solutions decompose in the presence of an MnO_2 catalyst into water and oxygen gas. Figure 20 shows a set up to prepare oxygen gas using this reaction and to collect samples of the gas formed in test-tubes.

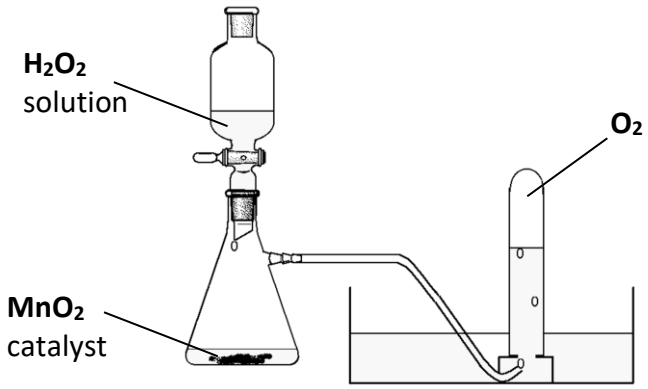


Figure 20

(i) The MnO_2 catalyst is a black solid.
Describe the appearance of hydrogen peroxide (H_2O_2) solutions. **3**
colourless …3

(ii) Write a balanced equation for the decomposition of H_2O_2 as described above. **2×3**
$H_2O_2 \rightarrow H_2O + ½O_2$ or $2H_2O_2 \rightarrow 2H_2O + O_2$ formulae correct …3
balanced ...3

(iii) What is the purpose of a catalyst in a chemical reaction? **6, 3**
to change the rate of reaction or to speed up reaction or to slow down reaction …6
without taking part in or getting used up in the reaction …3

Oxygen is a colourless, odourless gas.
(iv) Describe a test to confirm that the gas produced is oxygen. **6**
relights a glowing splint …6

(v) When collecting the oxygen, how could you tell when a test-tube was full of gas? **3**
all water pushed out …3

(vi) Give one commercial use of O_2 gas. **6**
steel-making / rocket fuel oxidant / oxyacetylene flame / welding or cutting metals / supports fuel combustion / combats pollution in water / beauty (skin) treatment / use in bomb calorimeter (measuring heats of combustion) / respiration or breathing by divers, pilots, sick people, etc. …6

(*b*) Consider the descriptions in the table relating to the electrolysis of molten sodium chloride (NaCl) using inert electrodes.

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

cathode anode Na^+ ions
oxidation reduction Cl^- **<u>9, 6, 3, 3×2</u>**

A	Loss of electrons during a reaction	oxidation
B	Negative electrode	cathode
C	Electrode where oxidation occurs	anode
D	Species oxidised during the electrolysis	Cl^-
E	Particles that conduct electricity through the molten electrolyte	ions
F	Gain of electrons during a reaction	reduction
G	Species reduced during the electrolysis	Na^+

any six**:** first correct …9, second …6, third …3, subsequent …3×2

What are the two products of the electrolysis of molten sodium chloride? **<u>2×3</u>**
sodium (metal) or Na …3
chlorine (gas) or Cl_2 …3

Suggest a suitable material for use as the inert electrodes. **<u>3</u>**
carbon or graphite or C or platinum or Pt …3

(*c*) Figure 21 shows limescale (mostly $CaCO_3$) on the surface of a chromium plated tap.

Limescale is formed when calcium hydrogencarbonate dissolved in water decomposes according to the following balanced equation:

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

(i) What is meant by a mole of a substance? **2×3**

[1]SI unit // [2]amount (of a substance) // [3]molecular mass or formula mass …3

[1]of amount (of a substance) // [2]that contains 6×10^{23} particles or atoms or molecules // [3]in grams …3

(ii) How many different elements are in the compound calcium hydrogencarbonate? **3**

4 …3

(iii) What is the mass of a mole of $Ca(HCO_3)_2$? **4, 2**

$40 + 2 \times (1 + 12 + (3 \times 16))$ …4

$= 162$ (g) …2

When 8.1 g of $Ca(HCO_3)_2$ decomposes completely, calculate

(iv) the number of moles of $Ca(HCO_3)_2$ which react **4, 2**

(n =) $\frac{m}{M_r}$ / (n =) $8.1 \div 162$ …4

= 0.05 (moles) …2

(v) the mass of $CaCO_3$ formed **4, 2**

0.05moles $CaCO_3$ formed …4

$(0.05 \times 100 =) 5$ (g) …2

(vi) the volume of the carbon dioxide formed, measured at s.t.p. **4, 2**

0.05 moles CO_2 formed …4

$(0.05 \times 22.4 =) 1.12$ (litres) …2

[H = 1; C = 12; O = 16; Ca = 40; molar volume at s.t.p. = 22.4 litres]