Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2016

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 / 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*) State the *principle of conservation of energy*. **5, 1**
energy cannot be created or destroyed / total quanity of energy (in universe) is constant …5
but energy can be converted from one form into another …1

(*b*) What is the SI unit of *work*? **6**
joule / J / newton metre / N m ...6
[accept millijoules, megajoules, etc …6]

(*c*) Figure 1 shows a soccer ball of mass of 445 g.
What is its mass expressed in kilograms (kg)? **6**
0.445 (kg) …6
[scaling by 10^3 to give 445000 ….3]

(*d*) A smartphone has a mass of 0.143 kg.
Calculate the weight of the phone.
[acceleration due to gravity, g = 9.8 m s^{-2}] **6**
1.4014 [1.4 – 1.43] (N) ...6
[(W =) mg ...3]

(*e*) Give one use for a concave mirror. **6**
brings light to a focus / magnification / in dentistry / (applying) make-up / (for) shaving / (reflector in) headlight or torch, etc …6
[reflection …3][use of convex mirror ….3]

(*f*) Figure 2 shows a waveform.
What term is given to the distance marked X? **6**
wavelength …6

(*g*) What is meant by the dispersion of white light? **5, 1**
splitting (white) light / separating (white) light //
into (its constituent) colours / into a spectrum / into different wavelengths
[5 + 1]

(*h*) Copper which is used in electrical wiring has a melting point of 1085 °C.
What is its melting point on the Kelvin scale? **6**
(1085 + 273 =) 1358 (K) ...6
[812 ...5]

(*i*) Copy and complete the following statement about how electric charges interact.
'Two positive charges ……. but a positive charge and a ……. charge attract.' **5, 1**
repel //
negative / unlike / opposite / different
[5 + 1]

(*j*) Copy Figure 3 that shows an isolated positively-charged conductor and sketch the electric field pattern around it. **5, 1**
field lines radiating from conductor …5
direction of field lines away from conductor …1

Figure 3

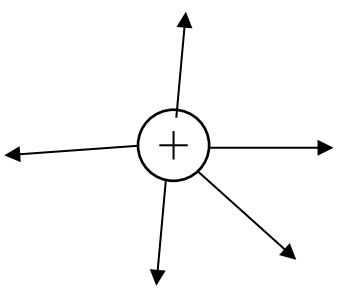


Figure 3 completed

(*k*) What is the replaceable safety component found inside a three-pin plug? **6**

fuse …6

[allow circuit breaker, earth …3]

(*l*) How could you detect a magnetic field? **6**

iron filings / compass (needle) / (response of) another magnet (in field) / deflection of a charged particle …6

(*m*) Figure 4 shows two 15 Ω resistors connected in parallel. What is the value of their combined effective resistance? **5, 1**

$\left(\frac{1}{R} =\right) \frac{1}{R_1} + \frac{1}{R_2}$ / $(\frac{1}{R} =) \frac{1}{15} + \frac{1}{15}$ …5

($\Rightarrow R =$) 7.5 (Ω) …1

[allow 30 (Ω) …3]

(*n*) Give one difference between nuclear fission and nuclear fusion. **6**

nuclei join in fusion / (large) nucleus splits in fission / fission easier to accomplish / less radioactive waste from fusion / material required for fission fuel scarcer than material required for fusion / fusion reactions provide energy of sun or stars …6

[allow atoms instead of nuclei]

(*o*) What is meant by the *half-life* of a radioactive substance? **5, 1**

time //

taken for half (a radioactive sample) to decay / to halve the activity (of a radioactive sample)

[5 + 1]

Question 2

(*a*) Define

(i) momentum, **6**

product of mass and velocity / mv or mu / $m \times v$ *or* $m \times u$ ...6

[product of mass and speed (–1)]

(ii) kinetic energy, of a moving object. **6**

energy due to motion / ½ mv^2 / ½ mu^2 ...6

[mv^2 ...3]

[omit to explain m and v or u (–1) but once only in part (*a*)]

Figure 5 shows two snooker balls each of mass 0.15 kg on a smooth horizontal table. Ball A is moving at a velocity of 0.8 m s^{-1} towards stationary ball B. After the collision ball A continues to move in the same direction as before but now it has a speed of 0.3 m s^{-1}.

Calculate

(iii) the initial momentum of snooker ball A **6, 3**

mv or mu / 0.15×0.8 …3

= 0.12 kg m s^{-1} (to the right) …6

[no unit or incorrect unit (–1)]

(iv) the velocity of snooker ball B after the collision **2×3**

$0.12 = m_1v_1 + m_2v_2$ / $0.12 = 0.15 \times 0.3 + 0.15 \times v$ / $0.12 = 0.045 + 0.15v$ / $0.075 = 0.15v$ …3

(v =) 0.5 m s^{-1} (to the right) / (v =) ½ m s^{-1} (to the right) …3

[no unit or incorrect unit (–1)][allow (4) for correct conservation of momentum formula with no calculation or incorrect calculation]

(v) the kinetic energy of ball A after the collision. **2×3**

½ $m_1v_1^2$ / ½$0.15(0.3)^2$ …3

0.00675 – 0.007 J …3

[no unit or incorrect unit (–1)][treat ½$0.15(0.8)^2$ as slip (–1)]

(*b*) Give two factors that affect the gravitational attraction between the sun and a planet. **2×6**

mass (of sun) / mass (of planet) / distance (between centres)

any two… 2×6

[allow distance from sun to planet]

Describe with the aid of a labelled diagram an experiment to measure the acceleration due to gravity, *g*. **2×3, 6, 3**

Arrangement of apparatus shown in diagram

pendulum: suspended bob, string //

freefall apparatus: ball, electromagnet, trapdoor or stop-start timing circuit //

freely falling object: timer, defined drop

any two…2×3

[no diagram - allow 3 max]

Procedure

pendulum: measure time for bob to complete one oscillation / measure length of string //

freefall apparatus: measure time for fall from electromagnet to trapdoor / measure drop //

freely falling object: measure time for object to fall from rest / through measured drop

any one…6

Measurements / Data handing

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

any one…3

Give <u>one</u> precaution to ensure an accurate result. **<u>6</u>**

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: average time for several falls or 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 //
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*) What is meant by the *refraction of light*? **5, 1**

bending / change of direction …5
(as light) travels from one medium to another …1

Give one difference between the conditions for refracting and reflecting light. **6**

reflection: (requires) a shiny surface / (requires) a smooth surface / only one medium involved, etc
refraction: (needs) a transparent medium / ray must strike boundary at an angle (to normal) / ray must not be perpendicular to boundary / two media involved, etc

any one…6

(*b*) Figure 6 shows the path of a ray of light through a triangular prism.

(i) Name the phenomenon that occurs at X. **6**

total internal reflection …6
[reflection ..... (–1)] [allow refraction / dispersion]

(ii) What is meant by the *critical angle*? **2×3**

angle of incidence (in denser medium) …3
corresponding to angle of refraction of 90º / which if exceeded results in total internal reflection …3
[marks available for good diagram.]

(*c*) Real images can be formed by lenses. **9, 3**

(i) Explain the underlined term.

(image) formed by intersection of light rays
[llow (image) formed on a screen]

(ii) What is the purpose of a lens in a camera?

to focus light / to make clear images (of objects at different distances), etc

first correct ...9, second correct ...3

(*d*) (i) Copy Figure 7 and complete it to show the formation of the image of object O by using any two rays. **9, 3**

first ray refracted correctly …9
second ray refracted correctly / image drawn in correct position …3
[arrows on rays not required]

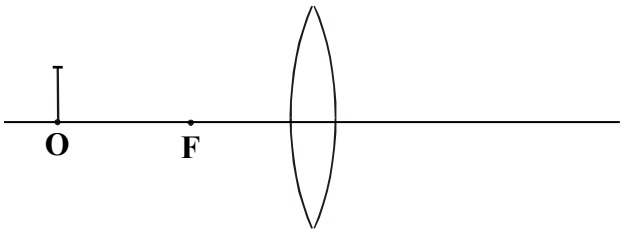


Figure 7

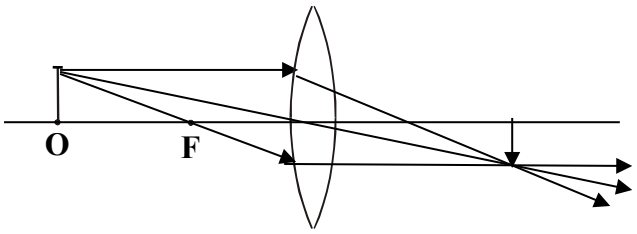


Figure 7 completed

The position of O is 14 cm from the lens that has a focal length of 7 cm.

(ii) Find the image distance from the lens. **5, 1**

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ...5

$\frac{1}{7} = \frac{1}{14} + \frac{1}{v} / \frac{1}{v} = \frac{1}{7} - \frac{1}{14} / \frac{1}{v} = \frac{1}{14}$

(v =) 14 cm ...1

[no unit or incorrect unit (–1)]

[calculation need not be shown for full marks to be given]

[diagrammatic / graphical approach acceptable]

(iii) Compare the sizes of the object and the image. **3**

(same) size …3

(iv) Is the image inverted relative to O? **3**

yes / inverted …3

(v) Where should the object be placed to form a magnified, real image? **6**

between focus and and 2*f* / between *f* and 2*f* / between 7 and 14 (cm from lens)

…6

[allow inside focus / inside *f* / less than 7 (cm from lens) …3]

[allow outside focus / outside *f* / more than 7 (cm from lens) ...3]

[award marks for information given diagrammatically here or as part of (*d*) (i)]

Question 4

In the seventeenth century, the Irish scientist, Robert Boyle, investigated the relationship between pressure and volume of a gas.

State *Boyle's law*. **5, 1**

pressure is inversely proportional to volume / $p \propto 1/V$ / pV is constant / $pV = k$ / $p_1V_1 = p_2V_2$ …5

for a fixed mass of gas at constant temperature …1

Describe an experiment to investigate Boyle's law. **6×3**

Arrangement of apparatus shown in diagram

quantity of gas in syringe or tube …3

scale to read volume or pressure …3

pressure guage or pressure sensor …3

[allow 3 (max) if no diagram][allow 6 (max) if no labels]

Procedure

read or record or take pressure /

read or record or take volume /

repeat (for new pressure and volume)

any two…2×3

Measurements / Data handing

draw a graph of p and $1/V$ or V and $1/p$ / pV is constant / $pV = k$ / $p_1V_1 = p_2V_2$ any one…3

Figure 8 shows a deflated balloon and an aerosol can containing compressed air at a pressure of 400 kPa. If 300 cm^3 of the compressed air were released into the balloon, which was then sealed, calculate the final volume of the balloon at a pressure of 100 kPa at the same temperature. **3×3**

$p_1V_1 = p_2V_2$ …3

$300 \times 400 = 100 \times V_2$ / $120000 = 100V$ …3

(V =) 1200 cm^3 / 1.2 litres …3

[no unit or incorrect unit (–1)]

In the eighteenth century the French scientist, Jacques Charles, investigated the relationship between volume and temperature of a gas.

State *Charles's law*. **5, 3, 1**

volume is proportional to temperature / temperature is proportional to volume / $V \propto T$ / $T \propto V$ / V/T is constant / T/V is constant / $V/T = k$ / $T/V = k$ / $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ / $\frac{T_1}{V_1} = \frac{T_2}{V_2}$ //

measured on kelvin or absolute scale //

for a fixed mass of gas at constant pressure

or

volume (of a gas) changes or increases or decreases by factor of 1/273th //

for every change or increase or decrease of temperature by 1 ºC //

for a fixed mass of gas at constant pressure

[5 + 3 + 1]

Both gas laws were later explained by the *kinetic theory of gases*.

Give two assumptions of the kinetic theory of gases. **2×6**

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…2×6

What is meant by the *ideal gas*? **2×3**

obeys all the gas laws / obeys Boyle's law / obeys any named gas law …3

at all temperatures and pressures / under all conditions …3

One mole of the ideal gas at standard pressure occupies 22.4 litres at 0°C (273 K).
State the volume theoretically occupied by the gas at a temperature of –273 °C (0 K). **6**

point volume / zero / no volume …6

[$pV = nRT$....3]

Question 5

(*a*) The following terms are used to state *Ohm's law*: **4×3**

proportional constant current potential difference

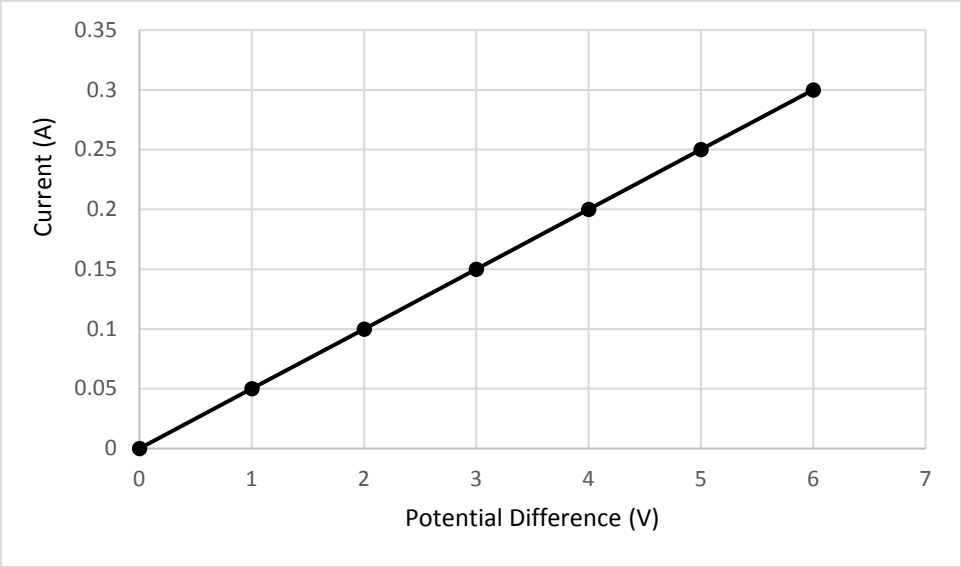
Using the above terms copy and complete the following statement of Ohm's law.
'The ……in a conductor is directly ……to the ……between its ends at …… temperature.'

current // potential difference …3
proportional ...3
potential difference // current …3
constant …3

A student collected the data below to investigate Ohm's law using a metallic conductor. **5×3**

potential difference (V)	**0**	**1**	**2**	**3**	**4**	**5**	**6**
current (A)	**0**	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**

Draw a graph (on graph paper) of current (*y*-axis) against potential difference (*x*-axis).
x-axis labelled potential difference or voltage or *V* or V …3
y-axis labelled current or *I* or amps or amperes or A …3
at least six points plotted correctly …3
joined by a straight line of good fit …3
through the origin …3
[allow 12 (max) if graph paper not used.]



Do you think that the data shows that the metallic conductor obeys Ohm's law? **2×3**
Give a reason for your answer.
yes …3
straight line through the origin …3

(*b*) Figure 9 shows a vacuum cleaner rated at 1300 W and connected to a 230 V a.c. supply.
State an energy change that takes place during its use. **5, 1**
electrical to //
mechanical / motion / kinetic / sound, etc

[5 + 1]

Calculate the current drawn by the vacuum cleaner at full power. **2×3**
$P = VI$ / $1300 = 230 \times I$ …3
(I =) 130/23 A = 5.65 – 6 A / 130/23 amps = 5.65 – 6 amps / 130/23 amperes = 5.65 – 6 amperes …3
[no unit or incorrect unit (–1)]

The vacuum cleaner was used at full power for a total of 2.5 hours in one week.
(i) How many units (kW h) were used? **2×3**
1.300 (kW) …3
1.3 × 2.5 = 13/ 4 (kW h) /3.25 (kW h) ...3

(ii) If the cost of each unit was 20 cent, calculate the cost involved. **6**
3.25 × 20 = 65 (cent) / €0.65 …6
[some work of merit ...3]

Explain why electrical power is transmitted over long distances at high voltages.
Name the device that can change the voltage of an a.c. supply. **6, 3**

saves energy / saves cost / avoids loss of power / avoids heat loss / at low voltages big loss (of heat, energy, power) due to resistance / economical, etc //

transformer

first correct…6, second correct …3

Question 6
Answer any two parts. **2×33**

(*a*) Define
(i) velocity, **2×3**
rate of change // speed // *s* ÷ ...3
of displacement // in a given direction // *t* ...3
[omit to explain *s* and *t* (–1)]

(ii) acceleration. **2×3**
rate of change // rate of change // *v* ÷ ...3
of velocity // of speed in a given direction // *t* ...3
[omit to explain *v* and *t* (–1)]

Figure 10 is a velocity-time graph for a horse in a race.
The horse starts from rest and reaches a velocity of 16.5 m s^{-1} in 5.5 seconds and maintains this velocity for the rest of the race. The horse crosses the finishing post 30 seconds after starting the race.

(iii) How long it takes the horse to complete the part of the race run at constant velocity? **3**
30 – 5.5 = 24.5 s …3
[no unit or incorrect unit (–1)]

(iv) Use the graph to estimate the velocity of the horse after 2.5 seconds. **6**
7.5 m s^{-1} [accept 7 – 8 m s^{-1}] …6
[no unit or incorrect unit (–1)]

Calculate
(v) the acceleration of the horse in the first 5.5 seconds of the race **2×3**
$v = u + at$ / $16.5 = 0 + (a \times 5.5)$ …3
(a =) 3 m s^{-2} / (a =) 3 m / s / s …3
[no unit or incorrect unit (–1)]

(vi) the distance covered in the first 5.5 seconds of the race. **2×3**
$s = ut + ½\ at^2$ / $s = (0 \times 5.5) + ½\ (3 \times (5.5)^2)$ …3
(s =) 45.375 m / [Accept (s =) 45 – 45.4 m] …3
[no unit or incorrect unit (–1)]

(*b*) Which part of an atom of a radioactive isotope is unstable? **6**
nucleus ...6

Give two uses for radioactive isotopes. **2×6**
medical use / to treat cancer / in diagnosis of illness / to detect leaks / to measure thickness / to preserve food / for archaeological dating / in smoke detectors / in bombs or weapons / in nuclear reactors or to generate electricity, etc any two…2×6

During one type of radioactive decay negatively-charged particles are emitted.
Identify this type of radioactivity. **6**
beta (radiation) / β (radiation) / electrons …6

Give two ways to deflect charged radiations from radioactive materials. **2×3**
(using an) electric (field) …3
(using a) magnetic (field) …3

Which type of nuclear radiation from radioactive materials cannot be deflected by these means? **3**
gamma radiation / γ-radiation …3

(*c*) Define *capacitance*. **2×3**

ratio of charge (stored) // Q // measure of ability of a conductor …3

to potential // ÷ V // to store energy electrostatically / to store charge …3

[reference to charge ….3]

State the SI unit of capacitance. **6**

farad / F …6

Which property of a capacitor allows it to be used in a flash light circuit of a camera? **3**

stores energy / stores (energy by separation of) charge …3

Figure 11 shows a circuit used to charge a parallel plate capacitor.
Copy the circuit and show the distribution of charges on the plates of the capacitor C. **2×3**

positive charge on left plate …3

negative charge on right …3

[reversed …5]

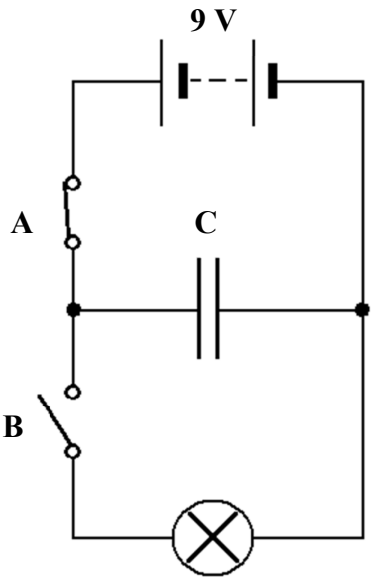


Figure 11

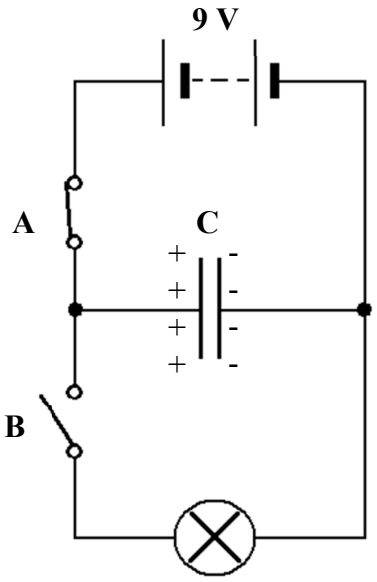


Figure 11 completed

What happens when switch A is then opened and switch B is closed? **6**

bulb lights …6

A capacitor connected to a 9 V battery has a charge of 1.5×10^{-6} C.
Calculate its capacitance. **2×3**

$C = \frac{Q}{V}$ / $C = \frac{1.5 \times 10^{-6}}{9}$ …3

$\frac{1}{6000000}$ / 1.66×10^{-7} (F) …3

(*d*) In 1921 Albert Einstein, shown in Figure 12, was awarded the Nobel Prize in Physics for his explanation of the *photoelectric effect*.
The effect can be demonstrated using the equipment shown in Figure 13.

2×9, 6, 3×3

(i) Name the piece of apparatus labelled A.
(gold-leaf) electroscope

(ii) Identify a suitable metal for M.
zinc

(iii) How is this metal prepared before use?
sanded / cleaned

(iv) Why is ultraviolet radiation suitable as the light source?
high frequency / high energy (photons)

(v) What is observed during this demonstration?
leaf or leaves collapse / leaf or leaves diverge (more)

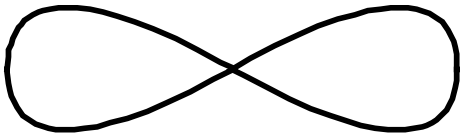
(vi) What does this tell you about the photoelectric effect?
negative charges or electrons released from metal (causing further divergence if electroscope negatively charged)
negative charges or electrons released from metal (causing less divergence if electroscope positively charged)

first two correct …2×9, third correct …6, last three correct…3×3

Question 7
Any eleven parts **11×6**

(*a*) Figure 14 is a photograph of a silicon chip. In the periodic table of the elements, what is the *group number* of the element silicon (Si)? **6**
14 / 4 / 4A …6

(*b*) Sketch the shape of a *p* orbital. **6**
dumbell …6



[*s* orbital …3]

(*c*) What type of bond arises between two atoms when an electron is transferred from one atom to the other? **6**
ionic (bond) …6

(*d*) Give one property of a transition element. **6**
metals or metallic / hard / strong / good catalysts / form coloured compounds, etc
any one…6

(*e*) How many (i) protons, (ii) neutrons, are there in an atom of argon, $^{40}_{18}$Ar? **5, 1**
(i) 18 //
(ii) 22
[5 + 1]

[reversed ….3]

(*f*) Copy and complete the statement:
'Allotropes, e.g. diamond and graphite, are different …… forms of the same ……' **5, 1**
physical //
element
first correct ...5, second correct ...1

(*g*) What happens to limewater in the presence of carbon dioxide gas? **6**
(turns) milky …6
[allow reacts ….3]

(*h*) Calculate the percentage of calcium by mass in calcium oxide (CaO). **2×3**
[O=16; Ca=40]
(M_r =) 56 ...3
$\frac{40}{56} \times 100 = 71.43\%$ …3
[5/7 ….5]

(*i*) Copy, complete and balance the following equation.
Zn + ____ → $ZnCl_2$ + H_2 **2×3**
HCl …3
Zn + 2HCl → $ZnCl_2$ + H_2 …3

(*j*) List the following metals in order of *increasing* activity:
aluminium sodium silver **6**
silver, aluminium, sodium …6
[allow reverse order …3]

(*k*) Calculate the number of atoms in the 9 moles of helium inside the balloons shown in Figure 15. [Avogadro constant = 6.0×10^{23} mol^{-1}] **6**

$9 \times 6.0 \times 10^{23} = 5.4 \times 10^{24}$ ...6

[$6.0 \times 10^{23} \div 9$ ...3]

(*l*) State *Hess's law*. **2×3**

heat change (for a reaction) …3

is independent of path taken / only depends of reactants and products …3

(*m*) Name the two gases produced when electricity is passed through acidified water. **5, 1**

hydrogen //

oxygen

first correct ...5, second correct ...1

(*n*) Draw the symbol used to represent the benzene molecule. **6**

…6

[allow cyclohexane structure…3]

(*o*) Figure 16 shows the structural formula of methanoic acid which is found in ant stings. Copy the structure and draw a circle around the acidic hydrogen. **6**

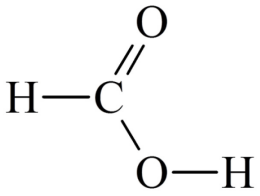


Figure 16

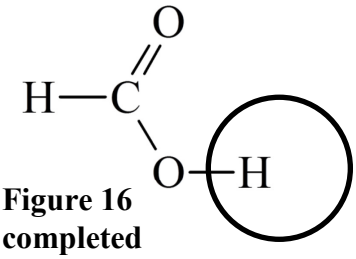


Figure 16 completed

…6

Question 8

(*a*) Define (i) atomic number **6**

number of protons / number of electrons in a neutral atom …6

[allow number of electrons in a neutral atom ...6][number of electrons …3]

(ii) mass number, of an element. **6**

number of protons and neutrons (in an atom of the element) / number of nucleons (in an atom of the element) / number of subatomic partcles (in an atom of the element) / mass (of an atom of the element) in amu …6

State (iii) the atomic number of an atom of oxygen, $^{16}_{8}O$. **6**

8 …6

(iv) Write the electron configuration (*s*, *p*) for an atom of oxygen. **2×3**

$1s^2\ 2s^2$ …3

$2p^4$ / $2p_x^2\ 2p_y^1\ 2p_z^1$ …3

[allow 2, 6 …3]

(*b*) The type of bonding in a compound is related to the electronegativity values of its component elements.

Define electronegativity. **2×3**

relative attraction / measure of power of attraction / measure of force of attraction …3

for electrons (in a shared pair or in a covalent bond) …3

['relative' or 'measure of' omitted (–1)]['in a shared pair' or 'in a covalent bond' omitted (–1)]

Use electronegativity values (page 81 of the *Formulae and Tables* booklet) to explain why the bonding in a water molecule is not pure covalent. **6**

(there is a) difference in electronegativity of hydrogen and oxygen / (3.44 –2.20 =) 1.24 / (3.44 – 2.20 <) 1.7 …6

[electronegativity values of hydrogen and oxygen given with incorrect or no justification…3]

Figure 17 shows a representation of a single molecule of water. **2×3**

Copy the diagram into your answerbook showing the location of

(i) a partial negative charge

δ– or – on or near oxygen …3

(ii) a partial positive charge.

δ+ or + on or near either hydrogen …3

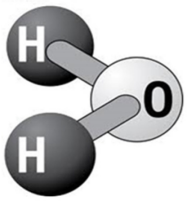


Figure 17

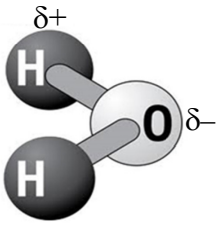


Figure 17 completed

State the shape of a molecule of water. **6**

v-shaped ...6

[allow planar …6]

(*c*) Figure 18 shows two views of water bulging on the surface of a coin. **9, 3×3**

What causes the water molecules to hold together as shown?

H-bonding / intermolecular forces / surface tension / water molecules bonding or clinging together / capillary action / surface tension

Why does water have a particularly high boiling point compared to other substances with molecules of a similar size?

H-bonds are strong(er than other intermolecular forces) / pure covalent substances or less polar substances have lower boiling points

Is water a good solvent for pure covalent substances?

no

Explain your answer.

no forces or attractions (between water and covalent substances)

[9 + 3 + 3 + 3]

Question 9

(*a*) What is (i) an acid, (ii) a base, according to the Brønsted-Lowry theory? **4×3**

(i) (an acid is a) proton / H^+ …3
donor …3
[allow acid produces H^+ (ions in solution) ...5]

(ii) (a base is a) proton / H^+ …3
acceptor …3
[allow base produces OH^- (ions in solution) ...5]

Identify
(iii) two bases,
(iv) one acid-base pair, in the following equation. **5, 1, 3**

$$\mathbf{CH_3COO^- + HCl \rightleftharpoons CH_3COOH + Cl^-}$$

(iii) CH_3COO^- //
Cl^-

[5 + 1]

[charge omitted .... (–1)]

(iv) CH_3COO^- and CH_3COOH / HCl and Cl^- …3

(*b*) Define pH. **6**

(pH =) $-\log[H^+]$ / (pH =) $-\log[H_3O^+]$ / (pH =) $-\log_{10}[H^+]$ / (pH =) $-\log_{10}[H_3O^+]$ / (pH =) minus the log (to the base ten) of the hydrogen ion concentration …6
[allow without []; plus charge omitted (–1)]

Calculate the pH of a 0.025 M solution of nitric acid (HNO_3). **5, 1**

(pH =) –log0.025 / (pH =) $-\log[H^+]$ …5
(pH =) –(–1.6020) = 1.6 …1

(*c*) Define reduction, in terms of electron transfer. **6**

(reduction is) gain of electrons …6
[allow 3 for words loss or gain where word electron is omitted; allow 3 for loss of oxygen or gain of hydrogen]

What other chemical process always occurs at the same time as reduction? **6**

oxidation / loss of electrons …6
[allow marks for reversed if consistent with candidate definition of reduction above]

Identify the substance reduced in the following reaction: $\mathbf{CuO + H_2 \rightarrow Cu + H_2O}$ **6**

CuO / Cu^{2+} / copper in CuO …6

What would you observe during this reaction? **6**

black CuO changes / to brown copper metal / steam or water droplets formed …6

Name the electrical process used to extract metals form their ores.
At which electrode does reduction occur during this process? **6, 3**

electrolysis
cathode / negative
[allow anode or positive …max 3]

first correct…6, second correct …3

Question 10

Using the glassware shown in Figure 19, a hydrochloric acid (HCl) solution of known concentration was added to a 25 cm^3 volume of sodium hydroxide (NaOH) solution to which a few drops of indicator had been added.

The equation for the reaction that occurred is:

$$\mathbf{HCl + NaOH \rightarrow NaCl + H_2O}$$

The *end point* was reached when 19.6 cm^3 of 0.18 M hydrochloric acid solution reacted with the sodium hydroxide solution.

(*a*) What name is given to this type of experiment? **6**

titration …6

(*b*) Identify the pieces of glassware labelled A, B and C. **3×3**

A: pipette …3

B: burette …3

C: (conical) flask …3

(*c*) Explain the term end point. **3**

when enough acid or HCl has been added (to react with or neutralise the base) /
when indicator changes colour …3

(*d*) How was the end point detected? **3**

using an indicator / colour change / using a pH meter …3

(*e*) How was A rinsed for use in this experiment? **6, 3**

with deionised or distilled water //
with base or NaOH

first correct …6, second correct …3

(*f*) Give one precaution when taking a reading from B. **3**

take reading where bottom of meniscus lies on mark / take reading from bottom of meniscus / burette should be vertical / read at eye-level / use solid background behind scale to make it easier to read

(*g*) C should be rinsed only with deionised or distilled water before use in this experiment. Why is tap-water not suitable for rinsing C? **6**

tap-water contains impurities / substances in tap-water could react / tap-water could contain acidic or basic substances / tap water would affect result …6

(*h*) Calculate the concentration of the sodium hydroxide solution used. **6, 3**

$\frac{V_1M_1}{n_1} = \frac{V_2M_2}{n_2}$ / $\frac{\mathbf{19.6 \times 0.18}}{\mathbf{1}} = \frac{\mathbf{25 \times M_2}}{\mathbf{1}}$ …6

(M_2 =) 0.14 – 0.14112 (mol/l) …3

The procedure was then repeated using the same quantities of acid and base but this time without the indicator.

(*i*) Explain how sodium chloride crystals can be separated from the reaction mixture in the conical flask. **6**

evaporation / heating …6

(*j*) Give two safety precautions when carrying out these experiments. **2×6**

wear gloves / wear goggles or eye protection / use a hair-tie / wear a lab-coat / mop-up any spills, etc

any two…2×6

Question 11

(*a*) Figure 20 shows a polythene plastic bag which is manufactured from the *hydrocarbon* gas ethene (C_2H_4).

Explain the term *hydrocarbon*. **2×3**

compond of carbon and hydrogen …3

only …3

Give one natural source of hydrocarbons. **6**

(natural gas) / coal / oil / ruminants / paddy fields / bogs / decomposition of organic waste in land-fill, etc …6

Ethane (C_2H_6) is another hydrocarbon gas whose molecules also contain two carbon atoms.

What is the structural difference between an ethene molecule and an ethane molecule? **6**

ethene has a double bond (between the carbon atoms) / ethane has all single bonds …6

[allow structures distinguished in diagrams …6]

Describe a chemical test which can confirm this structural difference. **5, 1**

add bromine solution / add acidified (potassium) permanganate or MnO_4^- and H^+ …5

decolourised in ethene / not decolourised by ethane …1

(*b*) Figure 21 shows part of a laboratory set up for the production and collection of ethene gas by passing vaporised ethanol over a solid C.

Identify solid C. **6**

aluminium oxide / Al_2O_3 …6

Explain how the ethanol

(i) is held at the end of the test tube **6**

(using) glass wool or cotton wool …6

(ii) is then vaporised. **6**

heating indirectly / heating the catalyst / applying a Bunsen burner (to tube under catalyst) …6

[allow applying Bunsen burner at ethanol or direct heating …3]

(*c*) Ethene burns exothermically in oxygen to form two compounds.

What is meant by an *exothermic* reaction? **6**

(reaction that) releases heat …6

Identify the two compounds formed. **2×6**

water …6

carbon dioxide …6

What type of flame is observed when a test tube of ethene is tested with a burning wooden splint? **6**

blue / luminous or yellow or bright / not very smoky or a little smoky …6

Question 12
Answer any two parts. **2×33**

(*a*) Methane reacts with steam under certain conditions to form hydrogen according to the following equation:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Give one commercial use for hydrogen. **6**
used to make ammonia / used in Haber process / used as a reducing reagent / used to hydrogenate oils / used in fuel cells / used as a fuel / used in airships / used in weather balloons, etc …6

What is meant by a mole of a substance? **6**
SI unit for amount (of a substance) / amount that contains Avogadro number or 6×10^{23} of particles or atoms or molecules / molecular or atomic mass in grams …6

When 32 g of methane is used in the reaction, calculate
(i) the number of moles of methane used **2×3**
(M_r =) 16 …3
32 ÷ 16 = 2 (moles) …3

(ii) the mass of hydrogen produced **3×3**
6 moles ...3
(M_r =) 2 …3
6 × 2 = 12 (g) …3

(iii) the volume occupied at s.t.p. by the hydrogen gas produced in the reaction. **6**
[H = 1; **C = 12**; **molar volume at s.t.p. is 22.4 litres]**
6 × 22.4 = 134.4 (litres) …6

(*b*) Oxygen gas is prepared in the laboratory by the addition of liquid A to solid B as shown in Figure 22.
(i) Give the names or formulae of A and B. **2×6**
A: hydrogen peroxide …6
B: manganese dioxide / liver / celery …6

(ii) Describe the appearance of solid B. **6**
black (powder) / dark brown (powder) / (very fine) powder / red meaty tissue / fibrous plant stems
any one…6

(iii) What is the purpose of solid B in this chemical reaction? **6**
catalyst / to speed up the reaction …6

(iv) Describe how a glowing splint is used to detect the presence of oxygen gas. **6**
relights (in presence of oxygen) …6

(v) Give one commercial use for oxygen gas. **3**
steel making / breathing aid in medicine or oxygen chamber in medicine or treat CO poisoning or treat pulmonary disease or treat muscle injury / use by emergency workers / use by divers or high altitude fliers or climbers / to burn rocket fuel / in fuel cells / oxyacetylene flame or welding and cutting metals / combat pollution / beauty or skin treatment / recreation (in oxygen bar) / in a bomb calorimeter, etc
any one …3

(*c*) Consider the descriptions in the table:

A	A substance capable of acting as an acid or as a base in a reaction
B	An element located in group 18 of the periodic table
C	A group of very reactive elements
D	A substance which does **not** cause litmus solutions to change colour
E	A binary compound containing the eighth element in the periodic table
F	A subatomic particle found in the nuclei of all atoms
G	A subatomic particle with a negative charge

In your answerbook match each term below with its description (A to G above).

proton	**electron**	**alkali metals**
amphoteric	**neutral**	**oxide**
noble gas		

3×6, 3×3

A = amphoteric
B = noble gas
C = alkali metals
D = neutral
E = oxide
F = proton
G = electron

first three correct ...3×6, second three correct... 3×3

What are *isotopes* of an element? **2×3**
atoms with the same atomic number / atoms of same element / atoms with the same number of protons (and) …3
different mass number / different number of neutrons / different masses …3

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