2023 Exam Marking Scheme

Section A - Criterion 4

<table>
<tr><th>Question</th><th>Answer</th><th>Marking Details</th></tr>
<tr><td>1a</td><td>
<table>
<tr><th>Subatomic Particle</th><th>Charge</th></tr>
<tr><td>Proton</td><td>+1 or
$+1.6 \times 10^{-19}$ C</td></tr>
<tr><td>Neutron</td><td>0</td></tr>
<tr><td>Electron</td><td>-1 or
$+1.6 \times 10^{-19}$ C</td></tr>
</table>
</td><td>Either relative charge or absolute charge accepted

1 mark total

0.5 marks deducted for each error</td></tr>
<tr><td>1b</td><td>
<table>
<tr><th>Electron Shell</th><th>Maximum number of electrons</th></tr>
<tr><td>1</td><td>2</td></tr>
<tr><td>2</td><td>8</td></tr>
</table>
</td><td>1 mark

1 mark</td></tr>
<tr><td>1c</td><td>Protons are positively charged.

Electrons are negatively charged.

The electrons are attracted to the protons in the nucleus by an electrostatic force of attraction (EFoA), which prevents them flying away.</td><td>As this was covered in part a) it was not required in part c)

1 mark

1 mark</td></tr>
<tr><td>1d</td><td>2, 8, 6</td><td>1 mark</td></tr>
<tr><td>1e</td><td>2, 8, 8</td><td>1 mark</td></tr>
<tr><td>1f</td><td>Cl^-, K^+, Ca^{2+}, P^{3-}</td><td>Any two accepted

0.5 mark each</td></tr>
</table>

Question	Answer	Marking Details
1g	All elements in period 3 have the same number of occupied electron shells. As you move across the period the number of protons or the nuclear charge increases. Therefore, there is an increasing EFoA between the nucleus and valence electrons. Therefore, the radii of the atoms decreases moving across the period.	Question is specific to period 3, so this was implied 1 1 No mention of electron shielding is required in PSC315118, this is only required in CHM41515

Comments for Question 1

This question was generally accessible for all students with the more successful students getting 8.5 and above.

a. While the majority of students wrote positive, neutral and negative and these were accepted for full marks, an indication of the magnitude as well as charge was desirable (e.g. +1, 0 -1). Some students may have misunderstood the question, or were confused by the table, as they referred to the generic model of an atom in the diagram above and gave a response of 7, 7, 7 (zero marks).
b. Responses were generally correct, although some students gave the total electrons (2, 10) so lost a mark.
c. The more successful responses included the term electrostatic force and described where the positive and negative charges were found in the atom. Students who stated that the protons were attracted to the electrons orbiting them did not gain full marks.
d. Mostly well answered.
e. Also correct in most instances.
f. A common mistake was selecting O-2 Se-2 rather than ions with 2,8,8 structures or nominating Si-4 which does not occur in nature.
g. Most responses earned at least part marks for this question but some claimed that electron numbers increase across period 3, and attributed the decrease in size to the increasing negative charge. These responses were penalised while the more successful answers described increased electrostatic force as a result of the higher atomic charge which decreased atomic radii.

<table>
<tr><th>Question</th><th>Answer</th><th>Marking Details</th></tr>
<tr><td>2a</td><td>$^{60m}_{27}Co \rightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma$</td><td>2 marks

(1 mark deducted if m was missing)</td></tr>
<tr><td>2b</td><td>Gamma rays have no mass or charge and travel at high speed (they are electromagnetic radiation).

Therefore, they only weakly interact with matter and can penetrate through thick pieces of metal.

Beta negative particles are electrons, which have mass and a -1 charge and travel slower than gamma rays.

Therefore, they interact with matter more readily and cannot penetrate through thick metal.</td><td>1 mark

0.5 mark

1 mark

0.5 mark</td></tr>
<tr><td>2c</td><td>Increase distance to source.

Decrease time near source.

Coat the emitter with something that will block beta particles (e.g. aluminium).</td><td>1 each for any two logical methods.

0.5 mark if only distance, shielding or time were stated without a method of protection</td></tr>
<tr><td>2d</td><td><table><tr><td>Activity (MBq)</td><td>100</td><td>50</td><td>25</td></tr><tr><td>Half-lives elapsed</td><td>0</td><td>1</td><td>2</td></tr></table>Therefore, it will have enough activity for 2 × 5.25 years = 10.5 years.</td><td>1 mark

1 mark</td></tr>
</table>

Comments for Question 2

Overall, students need to be reminded that "Explain why" questions require detailed reasons for the phenomenon, and if differences are to be explained, both situations need to be covered in their answer.

a. Some responses did not include the metastable symbol, with a worrying number placing the reaction arrow in the incorrect place.
b. This was a polarising question with some students just restating the question and quoting memorised degrees of penetration rather than explaining why the particles had different penetration properties. Solid responses compared the masses, speeds and ionisation properties of the two types of radiation, then explained how interactions with the material they passed through would impact their penetration.
c. The more successful students went into detail and described specific shielding examples and safe working distances for gamma radiation. Reference to efficient work practices that minimised

exposure time was also accepted, while only part marks were awarded for "protective clothing" type answers.

d. As always, some students mapped the halving of activity, but included the initial count as one half-life, so multiplied 5.25 by 3. Part marks were given for the working out.

Question	Answer	Marking Details
3a	Each of two or more forms of the same element that contain the same number of protons but different numbers of neutrons in their nuclei.	1 mark
3b	$121.8 = \frac{59.2}{100} \times 120.9 + \frac{40.8}{100} x$ $\therefore 121.8 = 71.5728 + 0.408\, x$ $\therefore x = \frac{121.8 - 71.5728}{0.408}$ $\therefore x = 123.1$ The mass of the second isotope of antimony is 123.1 units.	1 mark 2 marks

Comments for Question 3:

a. Student's responses needed to mention that the proton numbers remained the same while the neutron numbers changed. Part marks were given if students only mentioned different mass numbers.

Part marks were awarded if students were able to substitute correctly into relative atomic mass equation. Many students did not have the transposing skills required to complete the calculation. Those who did generally gained full marks.

Question	Answer	Marking Details
4a	${}^{239}_{94}Pu \rightarrow {}^{235}_{92}U + {}^{4}_{2}He$	2 marks
4b	${}^{1}_{0}n + {}^{239}_{94}Pu \rightarrow {}^{100}_{42}Mo + {}^{137}_{52}Te + 3({}^{1}_{0}n)$	1 mark
4c	Alpha decay is a spontaneous process that occurs in individual atoms. It does not lead to a chain reaction because it does not generate additional neutrons to trigger subsequent decay events in neighbouring nuclei. Each alpha decay event is independent of others and with a half-life of approx. 24000 years, there is a very low activity and hence, low rate of energy	1.5 marks

Question	Answer	Marking Details
	production. Therefore, alpha decay does not lead to a huge energy release. On the other hand, nuclear fission is a process where a heavy atomic nucleus, such as Pu-239, splits into two or more smaller nuclei, along with the release of energy and additional neutrons. These released neutrons can then go on to trigger the fission of other Pu-239 nuclei, creating a self-sustaining chain reaction. As the chain reaction accelerates, an exponential increase in energy production occurs.	1.5 marks

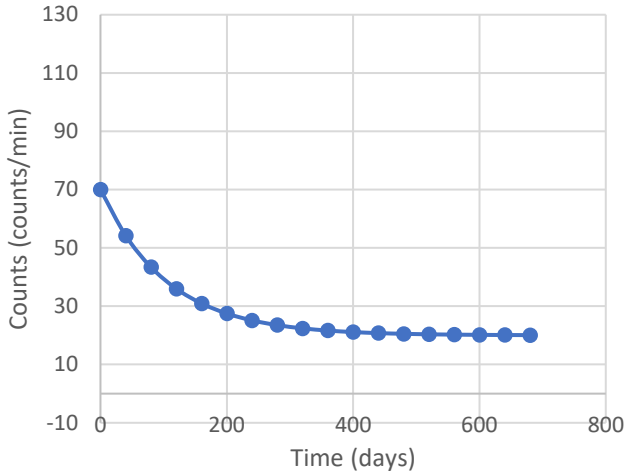
Comments for Question 4:

Overall, students should be reminded that when answering longer questions it is a good idea to step out their answer so that they can minimise repetition. Dot points that cover all required points gain more marks than rambling explanations that are repetitious or miss points.

a. Generally well done.
b. Mostly correct, but some students failed to include the mass of the incident neutron, or multiply the product neutron mass by 3, so their value for the mass of Te was incorrect.

The most common omission was that students did not talk about the difference in frequency of the two reactions. With a chain reaction, many fission reactions in a short period produce much more energy than an alpha that occurs with much less frequency due to a long half-life. Many students said more energy was released from a single fission than an alpha decay when they actually produce similar amounts of energy. The latter example gained no marks.

Question	Answer	Marking Details
5a	20 counts/minute	-0.5 marks for not including units.
5b	$^{192}_{77}Ir \rightarrow {}^{192}_{78}Pt + {}^{0}_{-1}e$	2 marks
5c	24.0 ng	When the sample is weighed after the time, the mass will be the same as the daughter isotope (platinum-192) has the same mass number as the iridium-192.

5d	 Initial count rate for 24.0 ng sample = 120 counts/min Background estimation = 20 counts/min Therefore, initial count rate of 24.0 ng sample due to iridium-192 = 100 counts/min. Therefore, initial count rate of 12.0 ng sample due to iridium-192 = 50 counts/min. Hence, initial count rate of 12.0 ng sample = 70 counts/min (including background).	1 mark for starting at 70 counts/min. 1 mark for approaching a horizontal asymptote of 20 counts/min. 1 mark for shape (second point at 73 days is approximately 45 counts/min.

Comments for Question 5:

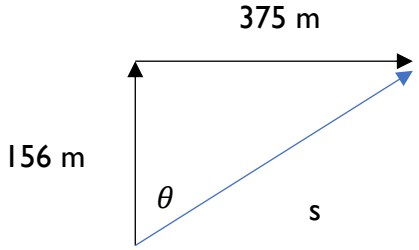
Overall, this was an "A" standard question with parts c) and d) being very challenging for most students.

a. Most students answered this correctly.
b. Some students were not able to structure this decay equation properly; those who identified the correct charge and mass for Iridium-192 and placed the arrow in the correct place were almost all able to balance the equation and gain full marks.
c. Only a handful of students understood the concept that mass is conserved with the majority completing half-life calculations. This wasted time and gained no marks in a one-mark question.
d. Few students recognised that the background count needed to be subtracted before repeatedly halving the activity of the sample, then adding 20cpm back on before plotting the graph. Part marks were allocated for correct shapes and finishing the graph at 20cpm. Some students simply halved all points on the graph in part a) though, and this was not given credit.

Part B – Criterion 5

In this criterion, there is a strong expectation that vector quantities will have direction and units correctly reported. In many instances students had 0.5 marks deducted for each failure to report directions or units correctly. The maximum that was deducted per paper however was 1 mark for inadequate reporting of vector directions and 1 mark for inadequate reporting of units.

Question	Answer	Marking Details
6a	$\frac{45.0}{3.6} = 12.5 \text{ m s}^{-1} \text{ North}$	-0.5 marks for no units -0.5 marks for no direction
6b	$v^2 = u^2 + 2as$ $\therefore a = \frac{v^2 - u^2}{2s}$ $\therefore a = \frac{12.5^2 - 0^2}{2 \times 156} = 0.501 \text{ m s}^{-2}$	-1 mark for incorrect significant figures (must be 3).
6c	$v = u + at$ $\therefore t = \frac{v - u}{a} = \frac{12.5 - 0}{0.501} = 24.96 \text{ m s}^{-1}$ $\therefore t = 25.0 \text{ s}$ Or $s = ut + \frac{1}{2}at^2$ $\therefore 156 = 0 \times t + \frac{1}{2} \times 0.501 \times t^2$ $\therefore t = \sqrt{\frac{2 \times 156}{0.501}} = 25.0 \text{ s}$ Or $v = u + at$ $12.5 = 0 + 0.501t$ $t = 24.96 \text{ s}$	1 mark
6d	$s = ut + \frac{1}{2}at^2$ $\therefore s = 12.5 \times 30.0 + \frac{1}{2} \times 0 \times 30^2$ $\therefore s = 375 \text{ m}$	1 mark

Question	Answer	Marking Details
6e	 $a^2 + b^2 = c^2$ $\therefore s = \sqrt{156^2 + 375^2} = 406\ m$ $\theta = \tan^{-1}\frac{O}{A} = \tan^{-1}\frac{375}{156} = 67.4°$ Displacement is 406 m N67.4°E	1 mark for vector diagram 1 mark for magnitude of displacement 1 mark for direction
6f	$v_{av} = \frac{s}{t} = \frac{406}{55} = 7.38\ \text{m s}^{-1}$ Average velocity = 7.38 m s^{-1} N67.4°E $\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{156 + 375}{55} = 9.65\ \text{m s}^{-1}$	0.5 marks for magnitude of velocity 0.5 marks for including direction 1 mark for speed calculation

Comments for Question 6

a. Many students did not recognise this question only involved converting the units of the final velocity given in the question and instead attempted to use equations of motion.
Those who were not able to complete part a) also found it difficult to complete calculations for parts b) to d).

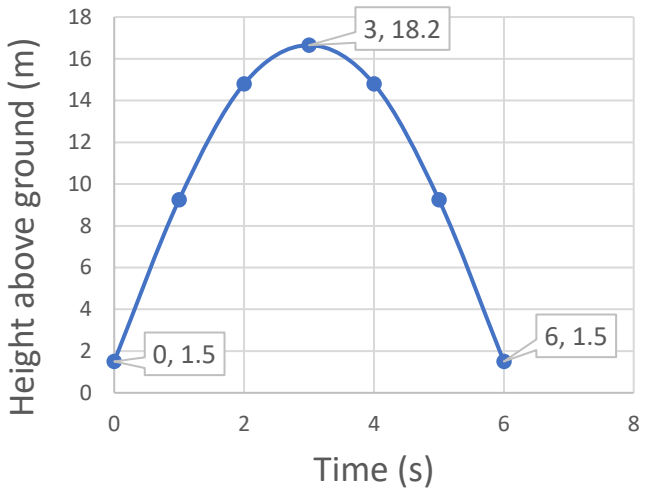
b. Reporting the answer to the correct number of significant figures proved to be problematic in many responses – some of those who did correctly report the appropriate number of significant figures made rounding errors, giving, for example, 0.500 rather than 0.501.

c. A variety of calculations were possible, with the simplest approach using $v = u + at$

d. Most responses to this question were correct.

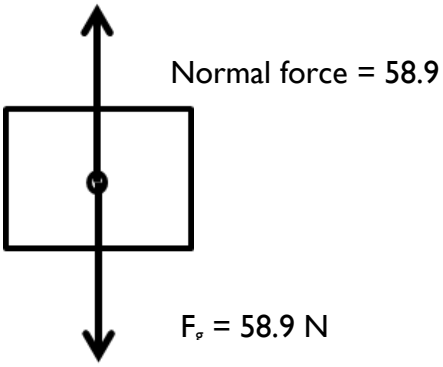
e. Most responses included a diagram that represented the situation; however, many did not include arrows on the vectors or label the angle used to calculate direction.
Quite a few responses only demonstrated calculation of the magnitude of the displacement but omitted the direction (angle) calculation.

f. This question was mostly answered well.
Some responses did not include the direction on the velocity, and the less successful responses seemed to indicate that the question wasn't fully read properly as only either a velocity or speed, but not both, was provided.

Question	Answer	Marking Details
7a	Acceleration = slope of velocity~time graph $\therefore \text{a} = \frac{\text{rise}}{\text{run}} = -\frac{11.1}{3} = -3.7 \text{ m s}^{-2}$ Hence acceleration is 3.7 m s^{-2} downwards	1 mark
7b	3 seconds	1 mark
7c	Displacement is area under velocity~time graph $\therefore \text{s} = \frac{1}{2}\text{bh} = \frac{1}{2} \times 3 \times 11.1 = 16.65 \text{ m}$ This is the displacement above the release height. Or $v^2 = u^2 + 2as$ $0^2 = 11.1^2 + 2 \times -3.7 \times s$ $s = \frac{-11.1^2}{2 \times -3.7}$ $s = 16.65$ (above starting height) Hence height above the ground = 16.65 + 1.5 = 18.15 = 18.2 m.	1 mark for calculation 1 mark for adding on the release height
7d		1 mark for parabolic shape 0.5 mark for axes titles 0.5 mark for point labels 1 mark for maximum at (3,18.2) and starting and finishing at (0,1.5), (6,1.5)

Comments for Question 7

a. Most students were able to answer this question correctly.
b. Most students were able to answer this question correctly.
c. Many students forgot to add the initial height of the ball to their calculation of displacement. Students could also answer this question using (suvat) equations of motion. However, it was very common for students to miss making a = -3.7 m s-2 in the equation.
d. Students should ensure that they meet the question requirements (label all axes and important points). A lot of errors were carried forward resulting in varying graph points due to mistakes in the previous part of the question.

Question	Answer	Marking Details
8a	$F_g = mg = 6 \times 9.81 = 58.9$ N down.	-0.5 for no direction
8b		0.5 marks for label 0.5 marks for magnitudes
8c	The weight force acting on block A is caused by a gravitational force of attraction down from the Earth. Newton's third law says every action has an equal an opposite reaction. Therefore, the reaction force to this weight force is the gravitational force of attraction upwards on the Earth from the block A.	2 marks for identifying the force of the Block on the Earth as the action/reaction pair to the weight force. 1.5 marks for description of Newton's Third Law AND outlining the other Newton's Third Law pair relevant to the situation: $F_{\text{Block on Surface}} = F_{\text{Surface on Block}}$
8d	$F = ma$ $\therefore a = \frac{F}{m} = \frac{12}{6+12} = 0.667$ m s^{-2} right	1 mark for rearranging F=ma

Question	Answer	Marking Details
		1 mark for correctly using the combined mass of the blocks.
8e	$F = ma$ $F = 12 \times 0.667 = 8.00$ N right	-0.5 for no direction

Comments for Question 8

a. Some responses indicated a confusion between mass and weight, stating that the weight was 6 kg; a misconception.

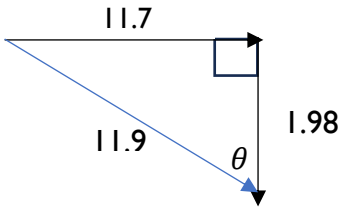
b. Many responses did not satisfy the full requirements of the question and only stated force magnitudes, or only labelled relevant forces on the diagram, not both.
This was also a common question for incorrect statement of units.

c. The weight force is simply the name given to the force that the Earth exerts on the Block. This is the gravitational force, which always acts on both interacting objects. E.g. the Earth exerts a force on the Moon while the Moon exerts an equal force on the Earth in the opposite direction.
Newton's Third Law pairs always act on different objects.
The forces shown in the diagram in Q8b are not a Newton's Third Law Pair because they act on the same object. The weight force acts on the block. The normal reaction force also acts on the block.
The Relevant Newton's Third Law Pairs involved in the scenario are:
   - The Earth exerts a force on the Block (the Weight Force) while the Block exerts an equal force in the opposite direction on the Earth.
   - The block exerts a force on the Surface while the Surface exerts an equal force in the opposite direction (the normal force) on the Block.

d. This was a challenging question for most students.
A very common mistake was failing to use the combined mass.

e. A very common mistake was the use of the incorrect mass (6 kg or 18 kg instead of 12 kg).

Question	Answer	Marking Details
9a	Vertical motion $v^2 = u^2 + 2as$ $\therefore v = \sqrt{u^2 + 2as}$ $\therefore v = \sqrt{0^2 + 2 \times 9.81 \times 0.20}$ $v = 1.98$ m s^{-1} downwards	-0.5 for no direction
9b	Vertical motion $v = u + at$	1 mark for time calculation

Question	Answer	Marking Details
	$\therefore t = \frac{v - u}{a} = \frac{1.98 - 0}{9.81} = 0.202\ s$ Horizontal motion $s = ut + \frac{1}{2}at^2$ $\therefore 2.37 = u \times 0.202 + \frac{1}{2} \times 0 \times 0.202^2$ $\therefore u = \frac{2.37}{0.202} = 11.7\ m\ s^{-1}$ *(right)*	1 mark for initial horizontal velocity Direction not required.
9c	 $\theta = \tan^{-1}\frac{11.7}{1.98} = 80.4°$ Or $\theta = \cos^{-1}\frac{11.7}{11.9} = 80.4°$ $\theta = \sin^{-1}\frac{1.98}{11.9} = 79.5°$	Note that the angle determined here depending on what trig ratio was used due to the rounded value of 11.9 m/s given in the question. If the angle to the horizontal was found 0.5 marks given

Comments for Question 9

a. Mostly well answered.

b. Many responses used 11.9 m s-1 as initial velocity, rather than identifying it as the resultant. A simpler solution is to use Pythagoras:

$$v^2 = v_x^2 + v_y^2$$
$$11.9^2 = v_x^2 + 1.98^2$$
$$v_x = \sqrt{11.9^2 - 1.98^2} = 11.73\ m\ s^{-1}$$

c. A very common mistake was to use the displacement vectors instead of the velocity vectors. The responses indicated that many students struggled with this question and identification of the correct angle.

Question	Answer	Marking Details
10a	Newton's first law. An object will continue in its current state of motion unless acted upon by an external unbalanced force. In the case of JUICE, in space there is not air resistance, so its motion is only affected by gravitational attraction to planets. Therefore, it can continue its motion without needed to continually use its engine.	1 mark for statement of Newton 1st Law 1 mark for the absence of frictional forces
10b	$\Delta p = F\Delta t$ $\therefore \Delta p = 425 \times (350 \times 60) = 8925000 \text{ N s}$ $\therefore \Delta \text{p} \approx 9 \times 10^6 \text{ kg m s}^{-1}$	1 mark
10c	$\text{u} = 12.1 \text{ km s}^{-1} = 12100 \text{ m s}^{-1}$ $\Delta p = mv - mu$ As JUICE is slowing down, the change in momentum is in the opposite direction to motion. $\therefore \quad -8925000 = 4180\text{v} - 4180 \times 12100$ $\therefore \quad \text{v} = \frac{-8925000 + 4180 \times 12100}{4180}$ $= 9965 \text{ m s}^{-1}$ $\therefore \quad \text{v} = \frac{9965}{1000} = 9.97 \text{ km s}^{-1}$ Therefore, JUICE will be succesfully slowed down to enter orbit.	1 mark for conversions between km/s and m/s 1 mark for interpreting the change in momentum to act opposite to the motion of the spacecraft 1 mark for calculation -0.5 for no final statement addressing whether the spacecraft slows sufficiently

Comments for Question 10

a. Relatively few responses identified the lack of friction forces in space. Most were able to describe Newton's First Law adequately. An important point to make is that it is more correct to refer to

unbalanced or net forces rather than 'opposing' or 'external' forces when describing Newton's First Law.

b. Many responses failed to apply the correct formula relating force and change in momentum, with confusion regarding momentum formulas present in criterion 6.

c. Many responses incorrectly converted km/s to m/s by dividing by 3.6.
The approach which involved calculating acceleration followed by final velocity was entirely valid. The simplest approach to this question uses the change in momentum previously calculated to determine the change in velocity:

$$\Delta p = m\Delta v$$

$$-8.925 \times 10^6 = 4180\Delta v$$

$$\Delta v = -2135 \text{ m s}^{-1}$$

$$\Delta v = v - u$$

$$-2135 \text{ m s}^{-1} = v - 12100 \text{ m s}^{-1}$$

$$v = 9965 \text{ m s}^{-1}$$

Part C- Criterion 6

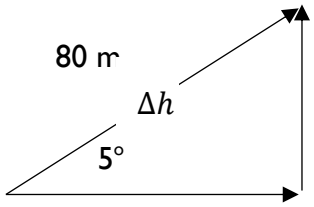
Question	Answer	Marking Details
11a	$\text{p} = \text{mv} = 0.156 \times 38 = 5.93 \text{ kg m s}^{-1}$ North	1 mark magnitude 0.5 mark units 0.5 mark direction
11b	$\text{m}_1\text{u}_1 + \text{m}_2\text{u}_2 = \text{m}_1\text{v}_1 + \text{m}_2\text{v}_2$ $\therefore \text{m}_1\text{u}_1 - \text{m}_1\text{v}_1 = \text{m}_2\text{v}_2 - \text{m}_2\text{u}_2$ $\therefore \text{m}_1(\text{u}_1 - \text{v}_1) = \text{m}_2(\text{v}_2 - \text{u}_2)$ $\therefore \text{m}_2 = \frac{\text{m}_1(\text{u}_1 - \text{v}_1)}{(\text{v}_2 - \text{u}_2)}$ $\therefore \text{m}_{\text{bat}} = \frac{\text{m}_{\text{ball}}(\text{u}_{\text{ball}} - \text{v}_{\text{ball}})}{(\text{v}_{\text{bat}} - \text{u}_{\text{bat}})}$ Define south as positive $\therefore \text{m}_{\text{bat}} = \frac{0.156((-38.0) - 42.4)}{(21.0 - 28.0)}$ $\therefore \text{m}_{\text{bat}} = 1.79 \text{ kg}$	1 mark for formula or relationship with numbers 2 marks for calculation and result
11c	Kinetic energy is not conserved	1mark -0.5 if kinetic is missing

Comments for Question 11

a. Most responses calculated momentum correctly but failed to give a direction.

b. This question was poorly done by most students with many not able to complete the momentum equation, and fewer able to solve it.

c. Many responses indicated that students did not know the definition of an inelastic collision.

Question	Answer	Marking Details
12a	$\mathrm{E_k} = \frac{1}{2}\mathrm{mv}^2 = \frac{1}{2} \times 78.0 \times 6.00^2 = 1.40 \times 10^3\ \mathrm{J}$	1 mark
12b	 $\sin\theta = \frac{O}{H}$ $\therefore O = H\sin\theta$ $\therefore \Delta h = 80 \times \sin 5 = 6.97\ m$	1 mark -0.5 mark for using tan θ
12c	$\Delta\mathrm{E_p} = \mathrm{mg\Delta h} = 78 \times 9.81 \times 6.97 = 5.34 \times 10^3\ \mathrm{J}$	1 mark
12d	$\Delta\mathrm{E_k} = \frac{1}{2}\mathrm{mv}^2 - \frac{1}{2}\mathrm{mu}^2$ $\Delta\mathrm{E_k} = \frac{1}{2} \times 78 \times 3^2 - 1404$ $\Delta\mathrm{E_k} = -1.05 \times 10^3\ \mathrm{J}$ Therefore, the rider lost 1053 J of kinetic energy whilst moving up the hill	0.5 mark for using 3ms^{-1} 0.5 mark for calculation
12e	$\mathrm{W} = \mathrm{Fs} = 6.10 \times 80.0 = 488\ \mathrm{J}$	1 mark
12f	$Energy\ change = \Delta E_p + Work + \Delta E_k$ $Energy\ change = 5335 + 488 + (-1053) = 4770\ J$ $\therefore P = \frac{\Delta E}{t} = \frac{4770}{18} = 265\ W$ Hence the scooter is illegal.	0.5 mark for using each energy form (1.5) 1 mark for power calc. 0.5 mark for analysing the legality of the scooter

Comments for Question 12

a. This calculation was generally well done.

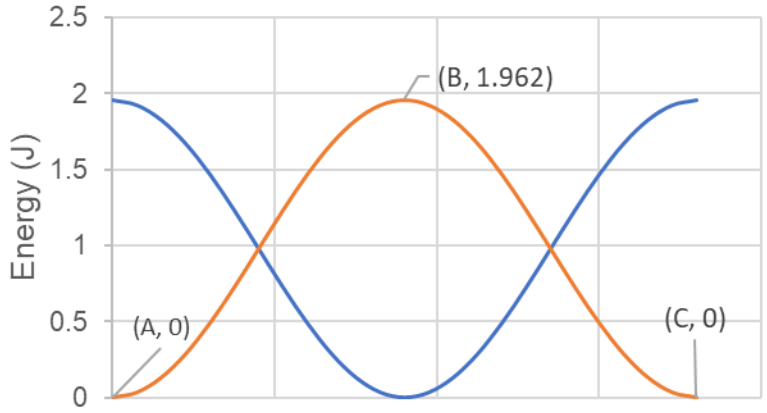
b. About half the responses recognised the appropriate trig relationship and used sine of the angle, but many used tan instead.

c. This calculation was generally well done.

d. This more challenging question was surprisingly well done.

e. This calculation was generally well done.

f. This question was poorly done – few students were able to assemble the various energy changes.

Question	Answer	Marking Details
13a	$E_p = mg\Delta h = 2.00 \times 9.81 \times 0.100 = 1.96\ J$	1 mark
13b	$E_k = E_p = 1.96\ J$	1 mark
13c	$E_k = \frac{1}{2}mv^2$ $\therefore v = \sqrt{\frac{2 \times E_k}{m}} = \sqrt{\frac{2 \times 1.962}{2.00}} = 1.40\ m\ s^{-1}$	1 mark
13d		1 mark for either y-intercept 1 mark for shape

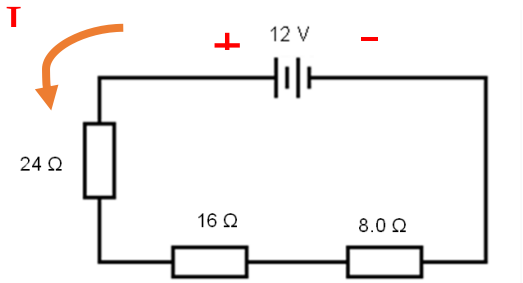
Comments for Question 13

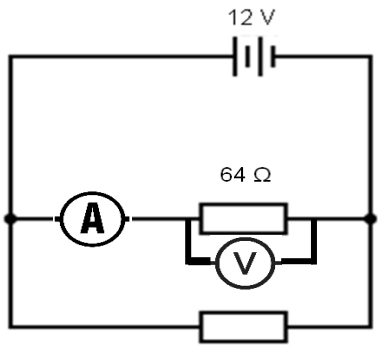
a. This calculation was generally well done.

b. This calculation was generally well done.

c. This calculation was generally well done.

d. Many students were able to sketch the appropriate graph but labelling the "y intercept" was misunderstood by many.

Question	Answer	Marking Details
14a	$R_{total} = R_1 + R_2 + R_3$ $R_{total} = 24 + 16 + 8.0 = 48\ \Omega$	0.5 calculation 0.5 units
14b	$V = IR$ $\therefore I = \frac{V}{R} = \frac{12}{48} = 0.25\ A$	0.5 calculation 0.5 units
14c		1 mark for correct current direction 1 mark for correct battery polarity (Errors in polarity were carried forward when marking current direction)
14d	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $\therefore \frac{1}{R_2} = \frac{1}{R_T} - \frac{1}{R_1}$ $\therefore R_2 = \frac{1}{\frac{1}{R_T} - \frac{1}{R_1}}$ $\therefore R_2 = \frac{1}{\frac{1}{48} - \frac{1}{64}} = 192\ \Omega$ Alternate equation OR alternate solution (using total current) with algebra earned full marks	1 mark for communication of reasoning 1 mark for correct working 1 mark for correct answer solution correct with units

Question	Answer	Marking Details
14e		1 mark for correct voltmeter placement 1 mark for correct ammeter placement -0.5 marks if words were used rather than device symbols

Comments for Question 14

a. Resistance calculation was generally well done.

b. Current was generally calculated well.

c. Less successful responses were unable to correctly label the battery polarity or give the direction of conventional current.

d. Some responses were able to give the appropriate equation but not able to solve it. A very few gave an alternative solution using data from the earlier series work (part a).

e. Reasonably well done, although a number of responses placed the ammeter in the main circuit rather than the 64Ω branch. Resistance calculation was generally well done.

Question	Answer	Marking Details
15a	Charging: Light energy → electrical energy (by the solar panel) Electrical energy → chemical potential energy (in the battery) Usage: Chemical potential energy → electrical energy Electrical energy → sound and light Heat energy is produced in each step.	1 mark for charging 1 mark for usage -0.5 for each missing transformation
15b	$q = It = 3200 \times 10^{-3} \times (60 \times 60) = 11520$	1 mark for correct working 1 mark for correct answer

Question	Answer	Marking Details
15c	$Number\ of\ electrons = \frac{total\ charge}{charge\ per\ electron}$ $number\ e^- = \frac{11520}{1.6\ \times 10^{-19}} = 7.2\ \times 10^{22}\ electrons$	0.5 marks for calculation 0.5 marks for correct number of electrons
15d	$V = \frac{\Delta E}{q}$ $\Delta E = Vq = 3.83 \times 11520 = 44121.6\ J$ $1\ Watt\ hour = 3600\ J$ $\therefore \frac{44121.6}{3600} = 12.3\ W\ h$	1 mark for energy in joules 1 mark for conversion to watt hours
15e	$time = \frac{12.256}{7} = 1.75\ hours$	1 mark

Comments for Question 15

a. Energy transformations were generally poorly described with many responses calling sunlight "heat" instead of solar energy, and many did not recognise the chemical potential energy of the battery.

b. The successful approaches saw the need to use I = q/t and the fact that I = 3200 mA = 3.2 A in order to be able to solve the question.

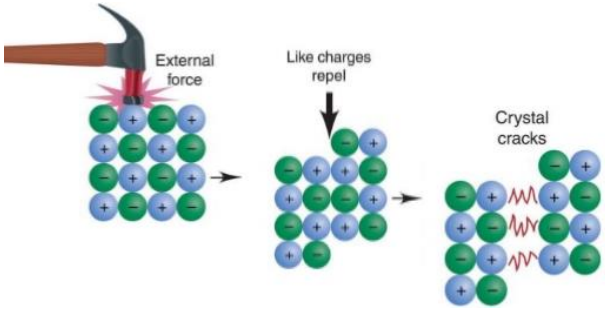
c. Less successful responses were commonly connected with failure to connect total charge to the number of electrons, or an inability to use the calculator correctly.
Many responses stated a negative number of electrons; this was penalised.

d. This question was poorly done with a common mistake of not recognising that Wh is an energy unit. Students tended to use power instead.

e. Few responses gave good reasoning for the answers they provided.

Part D - Criterion 7

In this Criterion, there is a need to read the questions carefully to ensure that the concepts of bonding being assessed are fully addressed. Rote responses can be efficient for recall but must be tailored to meet the question.

Question	Answer	Marking Details
16a	Strontium hydroxide Tin (II) nitrate	1 mark each -0.5 for not showing the charge on the tin ion.
16b	$Sn(NO_3)_{2\,(aq)} + Sr(OH)_{2\,(aq)} \rightarrow Sn(OH)_{2\,(s)} + Sr(NO_3)_{2\,(aq)}$ Or $Sn^{2+}_{(aq)} + 2\,NO^{-}_{3\,(aq)} + Sr^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Sn(OH)_{2\,(s)} + 2\,NO^{-}_{3\,(aq)} + Sr^{2+}_{(aq)}$	1 mark for correctly identifying precipitation product. +0.5 marks each for balance and states -0.5 marks for non-simplest ratio
16c	$Sn^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Sn(OH)_{2\,(s)}$	0.5 marks deducted for full ionic equation and for lack of (s) state on precipitate
16d	Ionic compounds have a structure consisting of a lattice of alternating cations and anions held together by electrostatic forces of attraction. High Melting Point: These forces are strong, and therefore require a large amount of energy to break. Therefore a high temperature is required to melt ionic compounds such as barium chloride. Brittleness: If a large force is applied to the ionic lattice, then like charges can align, which will cause an electrostatic force of repulsion between the like charges causing the crystal to shatter.  (use of an arrow showing force – instead of a hammer – is appropriate)	1.5 marks for each explanation

Comments for Question 16:

a. Many responses omitted the valency/charge of the tin in tin(II) nitrate.

Another common error was the inclusion of prefixes in the naming of ionic compounds. This is not necessary when valency/charge of the metal in an ionic compound is known.

b. Many responses failed to properly identify the precipitate as Sn(OH)2(s) . Combinations of the stated solutions containing other than Sn2+ and OH- would fail to produce a precipitate.

c. There was the possibility of error carried forward (ECF) for this question, depending on the response to the previous part of the question. However, a solid must still be the product; a net ionic equation cannot have all species in aqueous states.

d. More successful responses commonly included a diagram to help explain the brittleness of barium chloride. Unfortunately, the misuse of the terms intramolecular and intermolecular to explain the properties of an ionic lattice were far too common. Neither exist in ionic compounds.

Question	Answer	Marking Details
17a	3 **occupied** electron shells	-0.5 for not mentioning *occupied*
17 b	Most reactive ➡ Least reactive Sodium, magnesium, aluminium	1 mark for correct order
17c	Metals tend to lose electrons to gain a stable electron configuration. All three of these metals have three occupied electron shells; the valence shell is the 3rd shell. Aluminium has the highest nuclear charge (Z=13, the number of protons in its nucleus) and hence the greatest electrostatic force of attraction between its nucleus and valence electrons. Hence it has the lowest reactivity as it is the least likely to lose an electron. Conversely, sodium (Z=11) will have a weaker electrostatic force of attraction between its nucleus and valence electrons, hence it will be the most reactive.	1 mark for stating metals react by losing electrons. 1 mark for stating aluminium has the highest nuclear charge/greatest number of protons and sodium the lowest. 1 mark for relating the nuclear charge to the strength of the electrostatic force of attraction between the nucleus and valence electrons.
17d	Metals have a structure consisting of a lattice of metallic cations surrounded by a sea of delocalised electrons. When one end of the metal is heated: • the ions in the lattice can begin vibrating	0.5 marks 1 mark

Question	Answer	Marking Details
	• the electrons gain kinetic energy. As the electrons can readily move throughout the metal, they transfer the (translational) kinetic energy (heat) throughout the metallic lattice. Alternatively: As the ions vibrational energy is rapidly transferred through the lattice, heat is readily conducted.	0.5 marks

Comments for Question 17

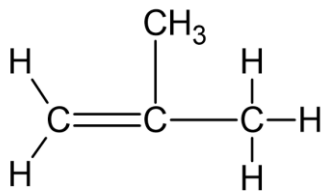
This question was unfortunately the most poorly answered. It was most directly related to the properties of metals with little extension or application to unknown/unusual contexts required.

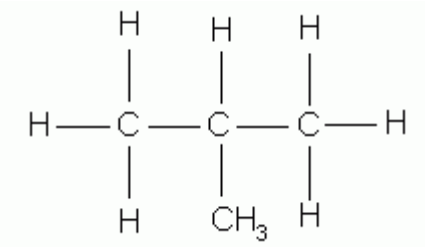
a. Many responses omitted the key term occupied.
There are many, many shells in an atom but only some are occupied by electrons, these occupied shells and the strength of their interaction with the nucleus dictate the chemistry.

b. Generally done well. However, the most common error was reversing the order or reactivity, even though the question prompted most reactive to least reactive.

c. This question required responses that explained the trends in reactivity, rather than simply describing them. Defining how metals react by losing electrons was a key element to successfully relating how easy this loss is to the electrostatic attraction between valence shell electrons and nuclear charge.
Students are discouraged in using uncommon abbreviations such as SDE, SODE.

d. Many responses discussed electrical conduction rather than heat conduction.
Conduction of heat relies on the transfer of kinetic energy (usually translational or vibrational). Relating the rapid transfer to the delocalised electrons or vibrating ions in the lattice was necessary to gain full marks. This last part of the answer was often omitted.

Question	Answer	Marking Details
18a	Reactant: Cl_2 Product: HCl	1 mark each for correct identification of reactant and product
18b	Name: methyl propene Or 2-methylpropene 	1 mark name 1 mark for structural formula
18c	Each of two or more compounds with the same molecular formula, but	0.5 marks

Question	Answer	Marking Details
	a different arrangement of atoms in the molecule (different structural formula)	0.5 marks
18d	2-chloro-2-methyl propane Or 2-chloromethylpropane 	1 mark for name 1 mark for structural formula
18e	Reaction B (This is a fast addition reaction to an alkene. Reaction A would be a slow substitution reaction)	1 mark

Comments for Question 18

Further attention to IUPAC nomenclature is encouraged, especially the correct use of dashes.

Students are also encouraged to always double-check the number of bonds on any given atom doesn't exceed its normal number of valence electrons (for example, the number of bonds around a carbon atom should be four).

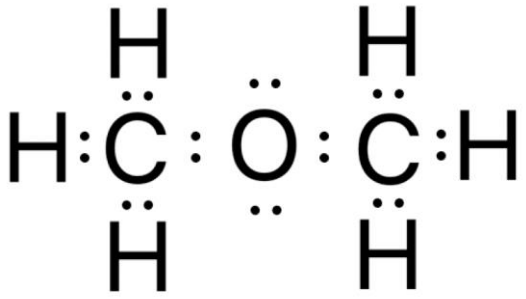
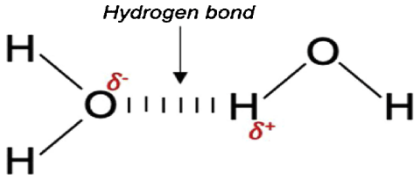
a. Elemental chlorine, Cl2, was the correct reactant. Many responses simply stated Cl. "Chlorine gas" was accepted as this will be in the elemental form under normal laboratory conditions. Usually if Cl was (incorrectly) stated as the reactant, H was (incorrectly) indicated as the product, instead of the required HCl.

b. Many responses named methyl propane (the product) instead of the reactant (2-methylpropene). Common errors also included too many bonds on a double bonded carbon atom and too many bonds on hydrogen atoms.

c. It is simplest to state "same molecular formula" instead of describing this. Compounds with the same empirical formula may not be isomers.

d. Many responses indicated that the instruction to draw an alternate isomeric product to Reaction B, was missed, and instead an isomer of the reactant was identified.

e. This question was generally answered well with most responses correctly identifying reaction B as the more rapid reaction (under laboratory conditions and in the absence of UV light).

Question	Answer	Marking Details
19a	Intermolecular bonds: Dimethyl ether, as a covalent molecular substance comprises of molecules which are held together by weak intermolecular forces. **When the substance boils, these intermolecular forces break** Intramolecular bonds: Dimethyl ether consists of atoms which are strongly bonded together through intramolecular covalent bonds. **These bonds are not broken in the boiling process.**	1 mark 1 mark
19b		1 mark for central atom possessing: • 2 lone pairs • 2 bonding pairs 1 mark for correct representation of methyl groups on either side of central O atom.
19c	Balanced Complete Combustion Equation : $C_2H_6O + \mathbf{3}O_2 \rightarrow \mathbf{2}CO_2 + \mathbf{3}H_2O$ Test: Bubble gas through limewater solution, if the solution turns cloudy, the gas is CO_2.	1 mark 1 mark
19d	Water is a polar molecule. (Water has a bent shape, and due to the presence of hydrogen atoms bound to oxygen is polar). The polar nature of water means that neighbouring molecules are attracted to each other through relatively strong intermolecular (hydrogen) bonds. As these intermolecular hydrogen bonds are stronger than the weaker (dispersion) forces between non-polar molecules, they take more energy to break and therefore water has a higher BP/MP than other similar covalent compounds.  	1 mark for stating water is polar 1 mark for discussing strength of intermolecular (hydrogen) bonds Diagram not required, but strongly encouraged.

Comments for Question 19

Students are encouraged to be mindful of question instructions to *'Describe', 'With reference … explain',* etc.

a. The most successful responses demonstrated a clear understanding of the difference between intermolecular (between the molecules) and intramolecular (within the molecules) bonds. Either "Intermolecular bonds are broken", or "bonds between the molecules are broken" was accepted.

b. Many diagrams were a mix of electron dot diagram and Bohr model.
Less successful responses replaced bonding pairs with lines. This simply reproduced the structural diagram provided in the introduction to the question.

c. No marks were deducted if a stoichiometric coefficient of "1" was provided for the C2H6O in the combustion equation. A common mistake in balancing for O2(g) was failing to account for the O atom in C2H6O.

Students were asked to describe a suitable test for the gases produced, not simply state the one used; a common mistake.

d. Students are strongly encouraged to, where possible, use a suitably annotated diagram to assist in explanations. The Physical Sciences course only requires students to understand water is a polar molecule and therefore possesses stronger intermolecular bonding compared to non-polar molecules. Greater bonding awareness is desirable but not assessable.

Question	Answer	Marking Details
20a	The term allotrope refers to the different forms of a chemical element that occur in the same physical state. The different forms arise from the different ways atoms may be bonded together.	
20b	As an abrasive: E.g., to coat drill bits, saw blades, sandpaper etc	
20c	Lonsdaleite, like diamond is not expected to conduct electricity. Diamond, like lonsdaleite, is a covalent network in which each carbon atom is covalently bonded to four other atoms. Therefore, there are no free electrons (or ions) which are free to move and conduct electricity. This is in contrast to graphite, which is a covalent layer lattice in which each carbon atom is covalently bonded to three other atoms in a 2D lattice, with one electron (per carbon atom) delocalised between the layers. These delocalised electrons are free to move and conduct.	1 mark for saying no and linking to diamonds structure 1 mark for saying diamond has 4 covalent bonds per atom. 1 mark for discussing the delocalised electron in graphite.

Comments for Question 20

This question was a clear discriminator of students able to apply their understanding of covalent network structures and properties to an unknown context.

a. Although the concept of allotropes is often associated in our course with carbon, it is not exclusively limited to carbon.

b. Practical suggestions for applications of Lonsdaleite were awarded marks.

   Constructing a building out of Lonsdaleite, for example, is not practical.

c. Many responses did not fully address the question by referring to the structures of diamond and graphite as well as Lonsdaleite. Less successful responses tried to link the strength of Lonsdaleite to the electrical conductivity of this allotrope, rather than consider its structure and the absence of delocalised electrons (in contrast to graphite) to carry electrical current.

Part E - Criterion 8

In this section, there were numerous questions requiring fairly routine calculations followed by an interpretation. This criterion proved very challenging for most candidates.

Question	Answer	Marking Details
21a	$M(C_6H_{12}O_6) = 6 \times 12.01 + 12 \times 1.008 + 6 \times 16.0$ $\therefore M(C_6H_{12}O_6) = 180.16\ g\ mol^{-1}$	1 mark -0.5 mark if calculation has only 4 sig fig (180.2)
21b	$n(C_6H_{12}O_6) = \frac{N}{N_A} = \frac{1}{6.02 \times 10^{23}} = 1.66\ \times 10^{-24}\ mol$ $n = \frac{m}{M}$ $\therefore m(C_6H_{12}O_6) = n \times M$ $\therefore m(C_6H_{12}O_6) = 1.66\ \times 10^{-24}\ \times 180.16 = 2.99\ \times 10^{-22} g$	1 mark for finding the number of moles 1 mark for mass calc.
21 c	$\therefore m(C_6H_{12}O_6) = n \times M$ $\therefore m(C_6H_{12}O_6) = 0.0277\ \times 180.16 = 4.99\ g$	1 mark
21 d	$c(C_6H_{12}O_6) = \frac{n}{v} = \frac{0.0277}{0.275} =\ 0.101\ mol\ L^{-1}$	0.5 mark for converting mL to L 0.5 mark for calculating concentration

Question	Answer	Marking Details
21e	$n(C_6H_{12}O_6)_{\text{in blood}} = c \times v = 2.00 \times 10^{-3} \times 5.00 = 0.0100 \text{ mol}$ $n(C_6H_{12}O_6)_{\text{in IV}} = c \times v = 0.101 \times 0.275 = 0.0277 \text{ mol}$ $\therefore n(C_6H_{12}O_6)_{\text{after IV}} = 0.0277 + 0.0100 = 0.0377 \text{ mol}$ $\therefore c(C_6H_{12}O_6)_{\text{after IV}} = \frac{n}{v} = \frac{0.0377}{5.275} = 7.18 \times 10^{-3} \text{ mol L}^{-1}$ Therefore, the patient is now hyperglycaemic.	1 mark 1mark 1 mark 1 mark

Comments for Question 21

There were obvious errors in calculator use for significant numbers of students. They need to know how to use scientific notation, particularly in calculations involving division.

a. Few responses earned full marks as they were not showing an answer with sufficient accuracy (5 significant figures).

b. Marks were deducted if 180.2 was used instead of 180.16. Some students appeared to confuse a mole with a molecule. They are not equivalent.

c. This calculation was generally well done.

d. When questions require "show that something equals approximately ..” students are required to give more significant figures than the approximate amount. Many students rounded to 0.1 molL-1 and were penalised.

e. Most attempted responses were reasonably strong. A common error was failure to use the quantity of glucose given in part d).

Question	Answer	Marking Details
22a	$\%\ H_2O = \frac{\text{mass of } H_2O}{\text{molar mass}} \times 100$ $\%\ H_2O = \frac{5 \times (2 \times 1.008 + 16.0)}{249.69} \times 100 = 36.1\ \%$	1 mark
22b	$m(H_2O) = \%\ H_2O \times \text{mass}$ $m(H_2O) = 0.361 \times 5.00 = 1.80 \text{ g}$	1 mark
22c	$m(CuSO_4) = 5.00 - 1.80 = 3.20 \text{ g}$ $m(H_2O)_{\text{in } CuSO_4.x\,H_2O} = 1.80 - 0.72 = 1.08 \text{ g}$	1 mark for determining the mass of $CuSO_4$

Question	Answer	Marking Details
	$\therefore \mathrm{n(CuSO_4)} = \frac{3.20}{159.6} = 0.0200 \quad : \quad \mathrm{n(H_2O)} = \frac{1.08}{18.016} = 0.0599$ $\therefore \mathrm{n(CuSO_4)} = \frac{0.0200}{0.0200} \quad : \quad \mathrm{n(H_2O)} = \frac{0.0599}{0.0200}$ $\therefore \mathrm{n(CuSO_4)} = 1 \quad : \quad \mathrm{n(H_2O)} = 3$ $\therefore \mathrm{CuSO_4.3\,H_2O}$	1 mark for determining the mass of water remaining 1 mark for empirical formula calculation

Comments for Question 22

The majority of students attempted this question but could not solve it. There were many possible ways to solve the question, but often responses were incomplete and did not clearly explain their logic.

a. Many students did not state that their solution was approximately equal to 35%

b. Some responses carried 35% into their calculations in this section, so gave inaccurate calculated answers.

c. While there were a variety of ways to reach a correct solution, some using simple ratio calculations, the majority of students found this question too challenging.

Question	Answer	Marking Details
23a	$\mathrm{n(AgNO_3)} = \mathrm{c} \times \mathrm{v} = 0.500 \times 0.856 = 0.428\ \mathrm{mol}$	0.5 mark for converting mL to L 0.5 mark for calculation
23b	$\mathrm{n(Ag^+)} = 0.428\ mol$ $\mathrm{n(Cl^-)} = 0.428\ mol$ $\therefore c(Cl^-) = 0.0428\ mol\ L^{-1} \times 35.45\ g\ mol^{-1} = 1.52\ g\ L^{-1}$ $\therefore c(Cl^-) = \frac{n}{v} = \frac{0.428}{10} = 0.0428\ mol\ L^{-1}$ $\therefore c(Cl^-) = 0.0428\ mol\ L^{-1} \times 35.45\ g\ mol^{-1} = 1.52\ g\ L^{-1}$ $\therefore c(Cl^-) = 1.52\ g\ L^{-1} \times 1000 = 1520\ mg\ L^{-1}$ Therefore, this cannot legally be discharged as it is above the legal limit of 1400 mg L^{-1}	1 mark for determining the number of mol of chloride ions 1 mark for concentration in mol/L 1 mark for converting to mg/L

Comments for Question 23

Many responses indicated that students found the context of the question confusing.

a. Many responses rounded their calculation to 0.4 mole rather than showing the correct number of significant figures.

b. While responses were reasonable here, it is evident that many students do not understand the correct way to respond to "show that" questions. Some students used the values given for AgCl or AgNO3 without explaining the 1:1 ratio to the Cl- concentration.

Question	Answer	Marking Details
24a	A diprotic acid is an acid that can donate two protons (or hydrogen ions) per molecule in an aqueous solution.	1 mark
24b	Thiosulfuric acid is a weak acid. This means that it will only partially ionise in solution. Sulfuric acid is a strong acid. Therefore, it will ionise to a greater extent. As pH is proportional to the concentration of hydrogen ions in solutions, (and a low pH corresponds with high concentration), thiosulfuric acid will have a higher pH then sulfuric acid.	1 mark for weak acids partially ionise 1 mark for strong acids fully ionise 1 mark for relating pH to concentration of hydrogen ions
24c	i. $H_2S_2O_{3\ (aq)} + 2NaHCO_{3\ (aq)} \rightarrow Na_2S_2O_{3\ (aq)} + 2H_2O_{(l)} + 2CO_{2\ (g)}$	0.5 mark for correct compounds 0.5 mark for states 1mark for balanced equation
24d	$n(KOH) = cv = 0.4153 \times 0.0212 = 8.80 \times 10^{-3} mol$ $n(H_2S_2O_3)\text{ in 20 mL aliquot} = \frac{n(KOH)}{2} = \frac{8.80 \times 10^{-3}}{2}$ $\therefore n(H_2S_2O_3)\text{ in 20mL aliquot} = 4.40 \times 10^{-3}\text{ mol}$ $\therefore c(H_2S_2O_3)\text{ dilute} = \frac{n}{v} = \frac{4.40 \times 10^{-3}}{0.0200} = 0.220\text{ mol L}^{-1}$	1 mark for mol calculation 1 mark for applying the stoichiometric ratio 1 mark for calculating concentration 1 mark for sig figs

Question	Answer	Marking Details
24e	10 mL of the thiosulfuric acid from the bottle was diluted to 100 mL. $\therefore c(H_2S_2O_3)$ bottle $= 10 \times 0.220$ mol L^{-1} $\therefore c(H_2S_2O_3)$ bottle $= 2.20$ mol L^{-1}	1 mark

Comments for Question 24

There were obvious errors in calculator use for significant numbers of students. They need to know how to use scientific notation, particularly in calculations involving division.

a. Many responses indicated that the term "diprotic" was not well understood. Some responses discussed 2 Hydrogen atoms rather than H+ ions or protons. Referencing atoms was penalised.

b. Few responses achieved full marks as they did not demonstrate understanding of the pH scale, or could not explain the difference between strong and weak acids in terms of dissociation and the number of available protons.

c. Reference to the information sheet should have reminded students that the products of a reaction between an acid and a hydrogen carbonate will include water (H2O) and carbon dioxide (CO2); the formula for the salt will hence be more easily determined. Sodium thiosulfate was rarely given as a product.

d. A number of responses used the dilution formula C1V1 = C2V2 when it is not appropriate in titrations, especially with diprotic acids. Other students reversed the mole ratios and multiplied rather than dividing the calculated amount of KOH. Some students mixed up volumes in their calculations – clear setting out is required to avoid this.
A value of 0.22 molL-1 was commonly stated, however this is only correct to 2 significant figures, not the required 3 significant figures.

e. This section was poorly done, with weaker responses failing to multiply the concentration in d) by the dilution factor. Using C1V1 = C2V2 was appropriate, but rarely applied, here.
Examiners strongly recommend that students use a sense of "reasonableness" when thinking about their responses. If a solution has been diluted 10 times, the original solution must have been 10 times more concentrated.

Question	Answer	Marking Details
25a	No. A Bronsted-Lowry base will accept a proton in a reaction with an acid such as hydrochloric acid. This is not occurring in this reaction, therefore, it is not reacting as a Bronsted-Lowry base.	0.5 mark for No 1.5 mark for definition of Bronsted-Lowry base

Question	Answer	Marking Details
25b	$n(H_2) = \frac{m}{M} = \frac{0.249}{2.016} = 0.124\ mol$ From the stoichiometric ratio in the equation: $\therefore n(X) = n(H_2) = 0.124\ mol$ $n = \frac{m}{M} \quad \therefore \quad M = \frac{m}{n}$ $\therefore \quad M(X) = \frac{3.00}{0.124} = 24.3$ Therefore, X is likely to be magnesium	1 mark 0.5 marks 1 mark 0.5 marks
25c	$n(MgCl_2) = n(Mg) = 0.124\ mol$ $M(MgCl_2) = 24.31 + 2 \times 35.45 = 95.21\ g\ mol^{-1}$ $\therefore m(MgCl_2) = n \times M$ $\therefore m(MgCl_2) = 0.124 \times 95.21 = 11.8\ g$	1 mark for molar mass calculation of $MgCl_2$ 1 mark for mass calculation

Comments for Question 25

This question was generally well answered by those students who attempted the last page of the last section of the exam.

a. The Bronsted-Lowry definition of a base was frequently not given, or well explained, in this question which required a response including "donated to" or "accepted by" to gain full marks.

b. This section was reasonably well answered, with most attempted responses able to apply the mole ratio and determine the charge on the element X.

c. If the response to part b) was correct, this part was generally correctly answered. Markers carried errors in b) forward to this section.