2025 ASSESSMENT REPORT
PSC315118 – PHYSICAL SCIENCES

Section A – Criterion 4

General Comments for Criterion 4

This was a very fair paper that allowed most students to demonstrate their understanding. Students who answered "explain" questions using Criterion 4 specific terminology and related their answers to the context of the question generally achieved higher marks than those who provided more generalised responses.

Students are reminded that simply restating the wording of the question is not an effective use of time or space and does not earn marks.

Question	Answer	Marking Details
1a)	B and C	1
1b)	2	1
1c)	Group 17 or VII Period 2	0.5 0.5
1d)i	A, C, D	1
1d)ii	A stable ion has a full outer shell C is stable D is stable	1 (marks also given to satisfying the octet rule. Noble gas configuration not awarded the full mark as it does not explain why they are stable) 0.5 0.5

Comments for Question 1

Overall, despite the relative ease of the questions, this item was not well answered.

1a) Frequently answered incorrectly, with many students choosing C & D due to having the same electron configuration rather than the same number of protons.

1b) Poorly answered. Very few students demonstrated an understanding that valency is the number of chemical bonds an element can form.

1c) Period number was generally well answered. However, many students made errors with the Group number, failing to recognise that the element was an ion. Students did not receive marks for writing "Group 7" instead of the correct Roman numeral "VII".

1d) Well answered by most students.

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Question	Answer	Marking Details
2a)	No of Protons: 92 No of Neutrons: 143 No of Electrons: 92	0.5 1 0.5
2b)	Any of the following: Mass, density, half-life(radioactivity), #neutrons.	1
2c)	$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + \boldsymbol{^{141}_{56}Ba} + 3{}^{1}_{0}n + Energy$	1 (Mass number) 1 (atomic number and chemical symbol)
2d)i	Neutrons produced from the fission reaction go on to collide with other U-235 nuclei and cause more fission (reaction becomes self-sustaining).	1
2d)ii	Excess neutrons produced by the fission reaction are absorbed by control rods to manage the rate of the fission (and hence the energy produced) .	1
2e)	160→80→40→20→10→5, i.e. 5 half lives ∴ 5 x 24000 = 120 000 years	1 working 1 correct answer
2f)	Alpha particle (Helium nucleus) Alpha is large and slow moving. It has a 2+ charge. Highly ionising. Alpha particles interact with (ionise) other particles and readily loses energy.	0.5 0.5 (describes any relevant alpha property) 1 (explaining how property relates to penetrating ability)
2g)	Thick lead/concrete walled container. Other suggestions which relate to shielding, distance, and/or time and protecting food and water sources.	1 (0.5 if only a material was suggested without a thickness or increasing distance)

Comments for Question 2

Overall, most students demonstrated an understanding of nuclear fission, half-life calculations, and the nature of alpha particle decay.

2a) Well answered.

2b) Generally well answered, though some students confused chemical and physical properties.

2c) Well answered. A common error was in calculating mass number, where some students did not account for all neutrons.

2d (i & ii) Students performed better when they described the number and behaviour of neutrons, particularly in the context of nuclear fission reactors.

2e) Generally well answered.

2f) Students often lacked detail, merely stating alpha particle properties without explaining how size and charge lead to more frequent interactions with other particles and rapid energy loss.

2g) Fairly well answered. Some students needed to specify that a certain thickness of concrete or lead was required, rather than just naming “a material”.

Question	Answer	Marking Details
3a)	metastable gamma	1 1
3b)	Electrical devices emit non-ionising EM radiation. Nuclear emit high energy α, β and γ ionising radiation.	1 (identifying which is ionising and which non-ionising)
3c)	20 counts/min	1 (-0.5 no units)
3d)	T½ = Time taken from 140—80 = 6 hours.	1 considering background radiation 1 using graphical data to show half life is time it takes for activity to halve. (-0.5 minor errors interpreting graph including units)
3e)	${}^{131}_{53}I \rightarrow {}^{0}_{-1}e + {}^{131}_{54}Xe$	0.5 beta particle 1.5 daughter nucleus
3f)	High doses are more likely to ionise and kill all the tumour cells with fewer treatments. AND Low dosage may damage or mutate the cell. This in turn may lead to cancer.	1.5 1.5

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Comments for Question 3

Overall, most students demonstrated understanding of reading half-life graphs and describing properties of beta particle decay. However, care is needed to apply this understanding within the context of the question.

3a) Well answered. (Gamma emissions were accepted as either particles or rays.)

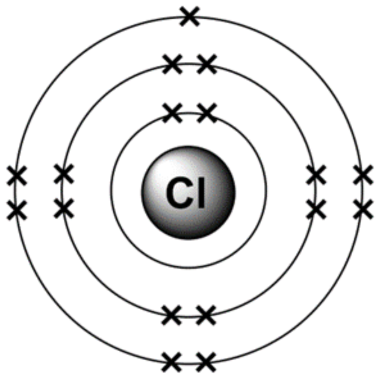
3b) Students should use the terminology specified in the course document, noting that these electrical devices emit non-ionising radiation and are not considered sources of background radiation (which is ionising). No marks were awarded for simply classifying one as dangerous and the other as safe.

3c) Well answered. Students are recommended to carefully check graph scales and ensure answers are given in the appropriate units.

3d) For full marks, students needed to consider background radiation. Full marks also required showing working mathematically or annotating the graph. While many students correctly noted that activity halves after each half-life, errors occurred when interpreting graph scales and accounting for background radiation.

3e) Well answered. Some students failed to show the beta emission on the RHS of the diagram.

3f) This was a challenging question, requiring knowledge of the application of radioisotopes for medical purposes. Many students did not discuss that ionising radiation can damage DNA and potentially cause cancer. Students who focused specifically on low vs. high dosage effects were awarded more marks than those who described only beta particle properties.

Question	Answer	Marking Details
4a)	They all have the same number of occupied electron shells.	1 (-0.5 not including ‘occupied’)
4b)		1
4c)	More protons in the nucleus. (17>12>11). Greater positive nuclear charge. This causes a greater electrostatic force of attraction to the nucleus. Thus, the electrons are drawn in closer and the radius is decreased.	0.5 1 0.5

4d)	To fill the outer electron shell create a stable electron arrangement Cl gains an electron. It now has 17+ and 18-, an overall charge of -1.	1 1
4e)	$$\frac{(90 \times 35) + (26 \times 37)}{(90 + 26)} = 35.448$$	1 method 1 interpreting mass spectrum and calculating correctly

Comments for Question 4

Overall, most students drew accurate electron shell diagrams and demonstrated understanding that the size of an atom's radius is determined by the electrostatic force between the positive nucleus and negative electrons.

4a) Students should include the term "occupied" in their answers, as all atoms have additional shells that could be accessed through processes such as electron excitation (e.g., flame tests).

4b) Well answered. Some errors occurred when students showed the structure of the ion.

4c) Students should explain that the increase in protons in the nucleus increases the electrostatic force of attraction. Simply stating that Cl has more electrons did not earn marks, as all three elements have the same number of occupied electron shells.

4d) Well answered.

4e) This was not a straightforward RAM question. Students needed to use mass spectrum data to calculate the % abundance. While most attempted this well, errors in the % abundance calculation were common.

Section B – Criterion 5

General Comments for Criterion 5

Overall, this section was challenging, with only Questions 5 and 8 being relatively straightforward for most students. General feedback indicates that students' understanding of physics concepts is weak. Common misconceptions were evident in relation to Newton's Laws, particularly confusion between Newton's Third Law and situations involving balanced forces. Mathematical skills were lacking across the cohort, and while some students demonstrated competency in algebraic manipulation, there were frequent issues with rounding and with carrying values correctly through multi-step calculations.

Positively, most students included units consistently in their responses and made effective use of the Information Sheet to source relevant formulas.

Question	Answer	Marking Details
5a)	Speed = distance/time $= \frac{13000}{7.0 \times 60}$ = 31 m s^{-1}	-0.5 for failing to convert km to m -0.5 for failing to convert min to s -0.5 for directly stating answer is 30 m s^{-1} without stating 31 m s^{-1} initially
5b)	30.9 x 3.6 = 111 km hr^{-1}	Sig fig calcs not penalised Note: ÷ 3.6 = 0 marks
5c)	Distance covered in 4 min = 25 x 4 x 60 = 6000 m Remaining distance = 13000 – 6000 = 7000 m New speed = distance/time = $\frac{7000}{3 \times 60}$ = 38.9 m s^{-1}	1 (-0.5 no working) 1 (-0.5 no working) 1 (-0.5 no working)
5d)	4 km	-0.5 for no unit
5e)	6 min	-0.5 for no unit
5f)	Fastest speed occurs at the steepest slope Steepest slope = $\frac{10-4}{(5-3) \times 60} = \frac{6000}{120}$ = 50 m s^{-1}	-0.5 for no calculations 180km/hr = 1 Note: 3 km/min = 0.5

Comments for Question 5

In this section, students generally scored well, as this was a straightforward question overall.

5a) Well done overall; however, many students provided only the final value rather than a complete response appropriate for a *"show that"* question.

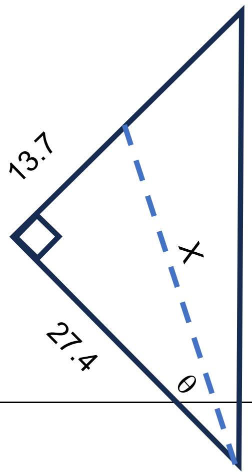
5b) As above, with the additional issue of students dividing by 3.6 rather than multiplying by 3.6.

5c) Students who attempted this generally performed well, although working was often difficult to follow. Marks were commonly lost for not clearly showing where the value of 7000 m was obtained.

5d) Well done.

5e) This was straightforward, but a number of students gave responses such as 6–7 mins or 7 mins, rather than correctly interpreting the graph. It should also be noted that the correct symbol for minutes is *min*, not *m* (which represents metres), and students were deducted 0.5 marks for this unit error.

This question should have been accessible; however, many students struggled. Responses such as 3 km/min were awarded ½ mark, while 3 km/h received no credit. A significant number of students also wrote 3 km/m, where *m* is not the symbol for minutes.

Question	Answer	Marking Details
6a)	27.4 x 3 = 82.2 m	-0.5 for no unit
6b)	27.4 m N 45.0° W (or NW)	0 mark allocated for no direction No half mark allocated: either 0 or 1
6c)	Velocity = s/t $= \frac{27.4}{13.5}$ = 2.03 m s^{-1} N 45.0° W	-0.5 for no working -1 for no direction -0.5 for no unit
6d)	 Pythagoras $X^2 = 27.4^2 + 13.7^2$ ∴ X = 30.6 m Tan $\theta = \frac{13.7}{27.4}$ ∴ θ = 26.6° (or 45.0 – 26.6 = 18.4°) ∴ Displacement = 30.6 m N18.4°W	1 = correct Pythagoras calculation 1 = correct trigonometry calculation 1 = correct final bearing and statement

Comments for Question 6

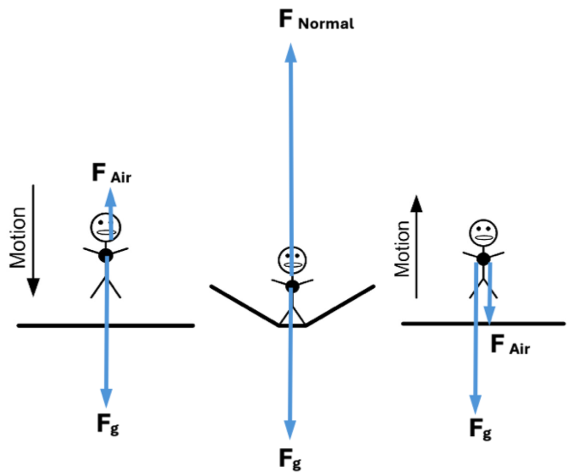
This question relied on general knowledge of baseball, which some students found challenging. A lack of understanding of compass bearings was also evident, indicating unfamiliarity with this concept.

6a) Generally answered well.

6b) The majority of students did not include a direction and therefore scored 0. Many students used incorrect descriptors such as “forwards”. Where the numerical value was correct but the direction was missing or incorrect, 0.5 marks were awarded.

6c) Most students scored the first mark; however, many again did not include a direction.

6d) Overall, this was a challenging question. As the inclusion of a diagram was not explicitly stated as a requirement, many students did not draw one and instead attempted to use motion equations rather than Pythagoras’ theorem, resulting in no marks being awarded. While many students were able to determine the trigonometric bearing, few scored the third mark, which relied heavily on constructing a clear and accurate diagram.

Question	Answer	Marking Details
7a)	Weight = mg = 21 x 9.81 = 206 N down	-0.5 for no direction -0.5 for no unit or using kg
7b)	Force of gravity on the Earth from the child or ($F_{\text{(child on Earth)}}$) or 206N up	1 mark Note: 0 if no direction given or mention of “from the trampoline” etc
7c)		1 = F_g on all 3 diagrams is labelled and the same size vector in all scenarios 0.5 = F_{Air} is smaller vector and in opposite direction than F_g in diagram one 1 = F_{Normal} is in opposite direction **and** greater than F_g in diagram two. 0.5 = F_{Air} is smaller vector and in the same direction than F_g in diagram three

7d)	Newton's 2nd Law Since $F = ma$ and/or $\mathrm{F} = \frac{\Delta \mathrm{p}}{\Delta \mathrm{t}}$, an increase in landing time will reduce the force of the childs landing, preventing injury.	0.5 mark 0.5 mark 0.5 mark 0.5 mark

Comments for Question 7

Overall, this question proved challenging for the majority of students.

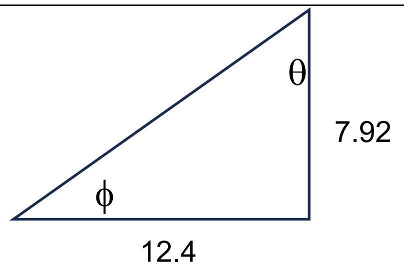
7a) This should have been accessible marks; however, most students did not include a direction and therefore lost marks. Many students incorrectly treated 21 kg as a weight, and/or used incorrect units such as J.

7b) This question highlighted common misconceptions between Newton's First Law (balanced forces) and Newton's Third Law (force pairs). Many students referred to trampoline or spring elasticity, not recognising that the child was in mid-air and therefore not in contact with the trampoline.

7c) This was an exceptionally poorly answered question. It is clear that many students do not understand free body diagrams. Approximately 90% of students did not draw force arrows originating from the centre of mass. There was widespread misunderstanding that F_g is equivalent to F_w. While most students identified air resistance, many incorrectly labelled it as friction and therefore did not score this mark.
The first diagram was the best answered overall. In the second diagram, many students incorrectly identified the net force as zero, stating that the forces were balanced because the person was stationary – again reflecting a common misconception. Force labelling was generally poor throughout. The third diagram was the second-best answered, though it still showed significant misunderstandings, including forces such as weight acting upwards.

7d) Most students scored at least one mark; however, many again incorrectly referenced Newton's Third Law and/or Newton's First Law. Few students identified injury reduction as the key reason, meaning 1.5 marks was the most common score among students who otherwise attempted the question well.

Question	Answer	Marking Details
8a)	$S = ut + \frac{1}{2}at^2 \quad \therefore t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \, x \, 3.20}{9.81}}$ = 0.808 seconds (3 s.f.)	0.5 for working 0.5 for answer given to greater than 1 significant figure
8b)	$v = \frac{s}{t} = \frac{10}{0.808}$ = 12.4 m s^{-1}	0.5 for working 0.5 for answer
8c)	$v = u + at = 0 + 9.81 \, x \, 0.808$ = 7.92 m s^{-1}	0.5 for working 0.5 for answer

8d)	 $v = \sqrt{7.92^2 + 12.4^2}$ = 14.7 m s^{-1} $Tan\phi = \frac{7.92}{12.4}$ $\therefore \phi = arctan\frac{7.92}{12.4}$ = 32.6° v = 14.7 m s^{-1} 32.6° below horizontal (3 s.f)	1 = correct calculations using Pythagoras 1 = correct determination of angle 1 = 3 significant figures in final statement with direction

Comments for Question 8

This was a straightforward projectile motion question, though it proved to be a discriminator, with students either performing well, not attempting the question or not scoring any marks. *"Show that"* questions require answers to be more precise than the values stated in the question, and values calculated should be carried through and used in subsequent parts. Errors in rounding were common, and weaknesses in algebraic skills affected many students, even when correct vector components were identified. Students should express angles in decimal degrees rather than minutes and seconds.

8a) Many students confused the vertical and horizontal components.

8b) Most students completed this part well, although some incorrectly used 0.8 s.

8c) Generally well done.

8d) As in Question 6d), most students did not draw a diagram, and many used displacement values rather than the vector quantities determined in earlier parts. It should be noted that *"below the horizontal"* is the expected terminology in these questions; however, many students used alternatives such as *forward and down*, *above the ground*, or similar descriptions. Most students achieved 1 mark but made multiple errors in angle calculations. This was the significant figures component of the question, which was handled poorly, and consequently very few students scored full marks. Students are advised to use decimal degrees rather than minutes and seconds in Physical Sciences Level 3.

Question	Answer	Marking Details
9a)	v = u + at $\therefore a = \frac{v-u}{t} = \frac{2.79}{300}$ = 0.0093 m s^{-2} North	0.5 for magnitude 0.5 for units No penalty if no direction included as stated in question
9b)	S = ut + ½ at^2 = 0 + ½ x 0.0093 x 300^2 = 420 m North	0.5 for magnitude 0.5 for direction
9c)	S = ut + ½ at^2 1380 = (2.79 x 200) + ½ a $(200)^2$ $a = \frac{2(1380-558)}{40000}$ = 0.041 m s^{-2} North	1 = working 0.5 = magnitude 0.5 = direction
9d)	v = u + at = 2.79 + 0.041 x 200 = 11 m s^{-1} North	0.5 working 0.5 magnitude No penalty if no direction included as stated in question
9e)	Trial 1 + Trial 2 = 420 + 1380 = 1800 m From 11 m s^{-1} North to stationary: $v^2 = u^2 + 2as$ $0 = 11^2 + 2 \times (-0.050) \times s$ s = $\frac{121}{0.1}$ = 1210 m N From stationary to 3.0 m s^{-1} South: $v^2 = u^2 + 2as$ $(-3)^2 = 0 + 2 \times (-0.050) \times s$ s = $\frac{9}{-0.1}$ = 90 m South ∴ total **distance** = 420 + 1380 +1210 + 90 = 3100m	1 = trial 1 + trial 2 1 mark 1 mark Note: 2 marks awarded if displacement found with working (2900m)

Comments for Question 9

This proved a very challenging question for students, with many leaving it unattempted. However, students who attempted it generally performed reasonably well.

9a) This part was reasonably well answered; however, many students used 150 s rather than 300 s and therefore did not score marks.

9b) Many students failed to use the acceleration calculated in the previous part, instead assuming constant velocity and using the $v_{\text{av}} = \frac{s}{t}$ equation. Many students also did not include a direction and therefore lost 0.5 marks.

9c) This part caused significant confusion. Many students used incorrect formulas, and those who selected the correct formula often assumed $u = 0$ rather than $u = 2.79$ m s^{-1}. Weak algebraic skills further limited success. Some students attempted to use the slope of the graph; however, this was problematic as the graph scale was not sufficiently precise and only allowed approximate values. While some credit was awarded for this approach, students should have recognised that the graph was schematic rather than drawn to scale, making it an unreliable method.

9d) This part was generally well done when the appropriate formula was used. As above, when the graph was used, approximations led to a wide range of answers.

9e) This was a challenging part, as many students did not recognise that the question asked for total distance rather than total displacement. Many students correctly added the distances from Trial 1 (9b) and Trial 2 (1.38 km). However, many attempted to recalculate values using areas under the graph, which introduced errors and was time-consuming, although some credit was awarded. Students who found the displacement for Trial 3 were awarded 1 mark; however, very few then added the additional 180 m. As previously noted, when the graph was used, approximations resulted in significantly different answers.

Section C – Criterion 6

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General Comments for Criterion 6

Overall, students were able to engage with this section well, especially questions that required use of a specific formula. The more mathematical components of the section were often quite structured and scaffolded, resulting in students answering appropriately.

However, questions that required written explanations of concepts or covered slightly more abstract elements were poorly answered, displaying a lack of deep understanding about the key ideas in this criterion for many students.

Students often displayed an incorrect use of units, rounding of final answers, inappropriate application of significant figures, or inability to work with scientific notation or prefixes. In addition, students should be encouraged to communicate working clearly, and to be aware that Criterion 5 content will not be assessed in Criterion 6.
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<tr><th>Question</th><th>Answer</th><th>Marking Details</th></tr>
<tr><td>10a)</td><td>Charge (electrons) is transferred to the girl from the Van de Graaff (or charge is transferred away from the girl).

so that each strand of hair develops the same charge.

Since each strand of hair has the same electric charge, an electrostatic force of repulsion (like repels like) results in the hair strands separating (standing on end)</td><td>0.5 mark

0.5 mark

1 mark</td></tr>
<tr><td>10b)</td><td>$number = \frac{-13.9 \times 10^{-6}}{-1.60 \times 10^{-19}}$
$= 8.69 \times 10^{13}\ electrons$</td><td>1 mark for unit conversion (microcoulombs to coulombs)

1 mark for calculation/answer</td></tr>
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Comments for Question 10

Overall, this question was done poorly, especially 10a).

10a) It was very clear that many students had a poor conceptual understanding of static electricity, especially the transfer of charge. Common errors involved the ‘flow’ of electrons, electrons ‘seeking’ to discharge or to be grounded, or the electrons moving to positive particles in the surrounding air and incorporating electrostatic attraction into the answer.

10b) Common errors included not changing the units, or doing so incorrectly, as well as calculation errors. A number of students multiplied the number of coulombs by the charge of an electron, rather than dividing.
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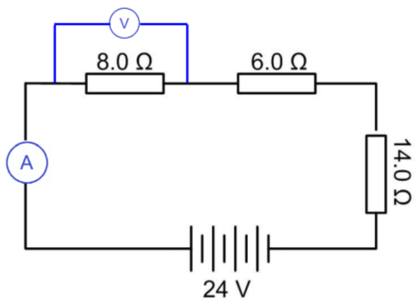
Question	Answer	Marking Details
11a)i	An ohmic resistor has a constant resistance, and its resulting V vs I (or I vs V) graph displays a linear (or directly proportional) relationship (i.e. a constant gradient).	0.5 mark 0.5 mark
11a)ii	Using gradient: $\text{slope} = \frac{\text{I}}{\text{V}} = \frac{1}{\text{R}}$ $\therefore \text{slope} = \frac{1}{8}$ $\therefore \frac{1}{8} = \frac{1}{\text{R}}$ $\therefore \text{R} = 8\ \Omega$ Using a point on the graph & Ohm's Law, for example $V = 8\ V, I = 1\ A$ $\text{R} = \frac{\text{V}}{\text{I}} = \frac{8}{1} = 8\ \Omega$	-1 mark for any calculation error
11b)	An ammeter symbol placed in series anywhere in the circuit. A voltmeter symbol across (parallel to) the 8 Ω resistor. For example,  	0.5 mark for each
11c)	$\text{R}_\text{T} = \text{R}_1 + \text{R}_2 + \text{R}_3 = 8.0 + 6.0 + 14.0 = 28\ \Omega$ $\text{V} = \text{IR} \therefore \text{I} = \frac{\text{V}}{\text{R}} = \frac{24}{28} = 0.86\ \text{A}$	1 mark 1 mark
11d)	$\text{R} = \frac{\text{V}}{\text{I}} = \frac{14.0}{0.636} = 22.0\ \Omega$	Accurate answer is 22.01 Ω, which is 22.0 Ω to 3 sig figs

11e)	$R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{22.0 \times 16.0}{22.0 + 16.0} = 9.26\ \Omega$	A range of answers were accepted here (9.26 Ω or 9.27 Ω) depending on the values by students
11f)	As $P = \frac{V^2}{R}$, and, in a parallel circuit, voltage drops are the same for both resistors, then the smaller resistor will provide the greater power output.	1 mark for the choice of formula 1 mark for explanation of the mathematical relationship

Comments for Question 11

Overall, done very well by most students as was quite straightforward and scaffolded.

11a)i Answers required two components to obtain the full mark, especially linking constant resistance with the linear graph provided in the stimulus. Many students answered one or the other, failing to link both parts. Answers that stated ‘follows Ohm’s Law’ were not accepted.

11a)ii The vast majority of students selected an easily read point from the graph and applied Ohm’s Law. A few students attempted to use the gradient of the graph in the stimulus but were then unaware that this was an I vs V graph, and the resistance was the inverse of the gradient.

11b) Generally answered correctly, although a few students did not use the correct symbols, or mixed up how these components are placed into a circuit.

11c) Many students failed to recognise that they needed to find the total resistance of the circuit before applying Ohm’s Law.

11d) Answered correctly by the almost all students, with calculation mistakes being the only common errors. Students had to show working out, as it was a ‘show that’ question.

11e) Answered correctly by the almost all students, with calculation mistakes being the only common errors.

11f) Students who talked about charge/current taking ‘the path of least resistance’ needed to link this to a higher current through the smaller resistor, and as voltage is the same for both, and $P = VI$, then a higher current gives a higher power output. A common error was to restate the question as an answer, or to mistake power for current or voltage.

Question	Answer	Marking Details
12a)	Solar/light energy is transformed into electrical energy (in the solar panels). Electrical energy is then transformed into chemical potential energy whilst being transferred to the car's battery. Chemical potential energy is transformed into electrical energy in the car's motor, which is then transformed into kinetic energy as the car moves. At each step, energy is transferred into the surroundings as heat energy etc.	0.5 mark for each key energy transformation -0.5 mark for each object involved in energy transfers missed 0.5 mark for heat energy etc losses
12b)	$P = \frac{\mathrm{W}}{\mathrm{t}}$ $\therefore \mathrm{W} = \mathrm{P} \times \mathrm{t} = 60.5 \times 10^3 \times 3600 = 2.18 \times 10^8\ \mathrm{J}$	- 0.5 mark for each conversion error
12c)	$E = V \times I \times t$ $2.18 \times 10^8 = 240 \times 30.0 \times \mathrm{t}$ $\therefore \mathrm{t} = \frac{2.18\times10^8}{240\times30.0} = 3.03 \times 10^4$ seconds Or $\mathrm{P} = \mathrm{VI} = 240 \times 30.0 = 7200\ \mathrm{W} = 7.2\ \mathrm{kW}$ t = $\frac{60.5\ \mathrm{kWh}}{7.2\ \mathrm{kW}} = 8.4$ hours	1 mark for calculating power (P) 1 mark for calculation of time (t) Either seconds or hours accepted

Comments for Question 12

This question was done relatively poorly by the majority of students.

12a) Students needed to describe the energy transformations, referencing the objects, as well as the different forms of energy involved in each key energy transfer for the full 4 marks. It was apparent that some students were not very familiar with how electric vehicles operate in a general sense. Common errors arose from incorrectly stating energy forms (e.g. heat energy being transformed by the solar panel), missing the key aspect of charging the car's battery (e.g. no electrical to chemical potential transformation), omitting key objects involved with transformations and transfers, and not mentioning loss of energy in the form of heat energy etc.

12b) Common mistakes included not correctly identifying the units, kWh, as a unit of energy, not converting to Watts, and not correctly converting hours to seconds. Students either handled this question well, or not at all.

12c) A variety of student approaches were seen, with the common response first calculating the power of the charging current. Students either handled this question well, or not at all.

Question	Answer	Marking Details
13a)	$p_A = m_A v_A = 1.71 \times 0.103 = 0.176 \text{ kg ms}^{-1}$ right $p_B = m_B v_B = 0.814 \times 0.39 = 0.317 \text{ kg ms}^{-1}$ right $p_T = p_A + p_B = 0.176 + 0.317 = 0.494 \text{ kg ms}^{-1}$ right Correct significant figures = 0.49 kg ms^{-1} right	1 mark for individual momentums 1 mark for total momentum 1 mark for correct sig figs
13b)i	$p_T = p_A + p_B$ $0.494 = p_A + (0.39 \times 1.41)$ $p_A = 0.494 - 0.550 = -0.0559 \text{ kg ms}^{-1}$ right $\therefore speed_A = \frac{0.0559}{0.103} = 0.54 \text{ ms}^{-1}$	1 mark for correct data and use of accurate value from 13a) 0.5 mark deducted if accurate answer not given
13b)ii	Left	No marks given if working from 13b) i) did not match or logically give this answer
13c)	$E_k(\text{after}) = \frac{1}{2} m{v_A}^2 + \frac{1}{2} m{v_B}^2$ $E_k(\text{after}) = \frac{1}{2} \times 0.103 \times 0.543^2 + \frac{1}{2} \times 0.39 \times 1.41^2 = 0.40 \text{ J}$ Since E_k (after, 0.40 J) does not equal E_k (before, 0.28 J), ∴ the collision is inelastic.	1 mark for calculation of E_k after collision 1 mark for comparison of E_k before and after 1 mark for logical conclusion based on evidence presented. A range of statements accepted here, as E_k has increased, so unable to ascertain for sure that this was elastic or inelastic

Comments for Question 13

The vast majority of students engaged well with this question as it was quite structured.

13a) Incorrect application of the appropriate number of significant figures was the most common error in 13a), together with no direction provided for final answer. A significant number of students rounded calculated values before a final answer was presented. An accurate value must be presented before stating that this was approximately the value provided.

13b)i A common mistake was to not use the conservation of momentum, or to use the approximate value for total momentum given in a), rather than the accurate value. Students needed to ensure that working is appropriate and not just manipulated to achieve the 'show that' value. This was vital, as a 'negative' value for the velocity was crucial to b ii).

13b)ii The direction stated in b) ii) must have been logically connected to the answer in part i) to be awarded marks.

13c) Was answered in a mixed manner. The question indirectly prompted students to calculate the total final E_k to compare to the total initial E_k. Many mistakes occurred in this calculation, including combining masses and velocities together, having a 'negative' E_k for movement in the left direction, failing to apply the E_k formula correctly etc. Many students then did not compare initial total E_k with final total E_k. To obtain full marks, students needed to have a logical concluding statement that matched the calculated and comparison evidence. A lot of leniencies were given here as E_k increased. A conclusive statement was only awarded a mark if it was justified. A lot of students only used a statement as their answer, but with incorrect definitions of elastic and inelastic collisions (eg as the trollies bounced apart, it must be elastic etc).

Question	Answer	Marking Details
14a)i	$E_k = \frac{1}{2}mv^2$ $E_k = \frac{1}{2} \times 1800 \times 14.8^2 = 1.97 \times 10^5$ J (or 197 kJ)	1 mark correct answer
14a)ii	$E_p = mgh$ $E_p = 1800 \times 9.81 \times 8 = 1.41 \times 10^5$ J (or 141 kJ)	1 mark correct answer
14b)	$W_{total} = 197 + 141 = 338$ kJ	Working required, as a 'show that' question -0.5 mark for leaving answer in J
14c)	$P = \frac{W}{t} = \frac{338}{12.2} = 27.7$ kW	1 mark correct answer
14d)	The car loses 1.41 x 10^5 J of E_p (from 14a above) as it goes down the slope at constant velocity. Since $W = Fs$ and $W = \Delta E$, then $F = \frac{W}{s} = \frac{\Delta E}{s} = \frac{1.41 \times 10^5}{50} = 2820$ N Force is opposite to the direction of motion (up the slope).	1 mark for $W = \Delta E_p$ 1 mark for calculation/answer - 0.5 mark for no/incorrect direction

Comments for Question 14

The first 3 parts were answered well, as these components were well structured and straight-forward. Incorrect use of units and scientific notation were common mistakes in these components.

14a) Failing to square the velocity when calculating E_k was the most common error.

14b) Most students were able to add the E_k and E_p to find the work done, although some students incorrectly subtracted E_p from E_k or used the $W = F \times s$ formula. Students had to express their final answer in kJ.

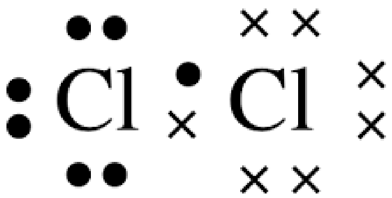
14c) Was done very well, with students using the provided answer in b) if they could not obtain a work value. The common error seen here was incorrect rounding of answer or incorrect units.

14d) Proved to be problematic for most students. Many students did not recognise that the loss of E_p was the work done by friction. Incorrect units for force, or a lack of an appropriate direction were other common mistakes. A significant number of students used weight calculations as part of an attempted answer, despite this being the Criterion 6 section. Some students attempted to work out the 'constant velocity', despite this not answering the question.

Section D – Criterion 7

General Comments for Criterion 7

Overall, students need to provide concise but sufficiently detailed responses in order to access the full range of marks that reflect their understanding. Success in this criterion requires students to consistently use correct scientific notation and terminology, while clearly explaining their reasoning.

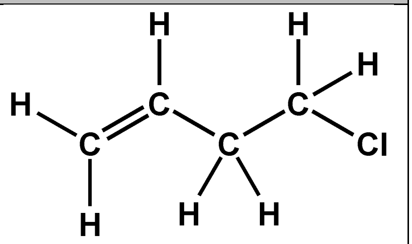
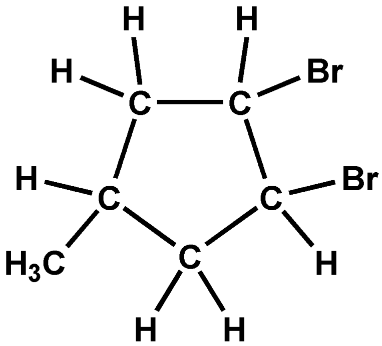
Question	Answer	Marking Details
15a)	They have the same number of / 7 valence electrons in their outer shell	1 mark
15bi)	They readily accept an electron to form a stable or full outer shell/configuration	0.5 mark 0.5 mark
15bii)	Going down the group, the size of the atom increases / increased number of occupied electron shells. This reduces the electrostatic attraction from the nucleus to the valence electron shell and hence reduces its ability to attract/accept an electron.	1 mark 0.5 mark 0.5 mark
15c)	Cl_2  C_2H_3Cl  	1 mark 1 mark

Comments for Question 15

a) Generally, well done.

b) Generally, well done. However, students who answered 15a thoroughly often repeated themselves in 15b(i).

c) On the whole, students struggled with electron dot diagrams (especially C_2H_3Cl). Advice for future students is to practise electron dot diagrams of organic compounds.

Question	Answer			Marking Details
	Systematic Name	Empirical Formula	Structural Formulae	
16)	**Carbon disulfide**	CS_2		1 mark for each correct box 0 if carbon sulfide
	Silver carbonate	**Ag_2CO_3**		0 if any error
	Tin (IV) chromate	$Sn(CrO_4)_2$		0 if tin chromate
	4-Chloro-but-1-ene	C_4H_7Cl		-0.5 for H missing
	1,2-dibromo-4-methylcyclopentane	**C_3H_5Br**		- 0.5 for "di' missing - 0.5 every error 0.5 for molecular formula ($C_6H_{10}Br_2$)

Comments for Question 16

Exam technique: Students are reminded that greyed-out boxes in tables do not need to be completed.

The basic skill of systematically naming covalent molecular substances using prefixes was done poorly (e.g. CS_2). Students are reminded to make thorough use of the Information Sheet.

At TCE Physical Science level, it is expected that transition metal cations are named appropriately (e.g. tin (IV) chromate). Teachers are encouraged to ensure students have sufficient practice in this area, as many students did not receive marks for this part.

Only a minority of students correctly identified the empirical formula; most instead provided the molecular formula. *Exam technique:* students are reminded to use reading time effectively and to highlight key information in the question.

Question	Answer	Marking Details
17a)	Bonding present = metallic Reason (a diagram showing cations surrounded by sea of delocalised electrons assists) – Iron is hard since the metallic bonds are strong. The strong bonds are multidirectional bonds (sea of delocalised electrons) and allow the cations to move past each other allowing the metal to deform or be malleable.	1 mark 0.5 mark 0.5 mark
17b)	Bonding present = ionic. Reason: The strong ionic bonds creating a fixed, rigid lattice where there are no charged particles to pass a current. When molten/aqueous the ions can move and hence pass a current.	1 mark 0.5 mark 0.5 mark
17c)	Bonding present = covalent **molecular** Reason: Water has strong intramolecular covalent bonds that are not easily broken. It has a high BP due to the relatively strong intermolecular forces created due to the water molecule being highly polar.	1 mark (-0.5 for just covalent) 0.5 mark 0.5 mark

Comments for Question 17

The type of bonding was generally identified well in all parts. However, many students addressed only one of the listed properties rather than both (e.g. explaining malleability for metals but not hardness), and therefore received partial marks. The ionic material was addressed most successfully overall, while the material involving water proved the most challenging for students.

Question	Answer	Marking Details
18ai)	$Ba(NO_3)_{2(aq)}$ + $Na_2SO_{4(aq)}$ → $BaSO_{4(s)}$ + $2NaNO_{3(aq)}$	1 mark for correct equation 1 mark for balanced correctly - 0.5 mark for incorrect/missing states
18aii)	$Ba^{2+}_{(aq)}$ + $SO_4^{2-}{}_{(aq)}$ → $BaSO_{4(s)}$	1 mark - 0.5 mark if charges on products
18b)	Na^+ and NO_3^-	0.5 mark per ion
18c)	$Ba(NO_3)_2$ does not form a precipitate when added to NaOH (i.e. $Ba(OH)_2$ is soluble). But $Ba(NO_3)_2$ does form a precipitate when added to Na_2SO_4 (i.e. $BaSO_4$ is insoluble).	0.5 mark 0.5 mark
18d)	Flame test	1 mark Note: Other reasonable answers accepted

Comments for Question 18

This question proved challenging for many students, primarily due to issues with technique and nomenclature, rather than a lack of conceptual understanding.

18 (a & b) Students need to be more careful with the use of charges. When ions are specifically requested, charges must be shown; conversely, they should not be included in neutral compounds.

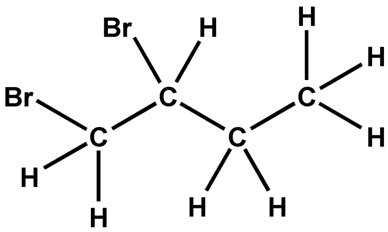
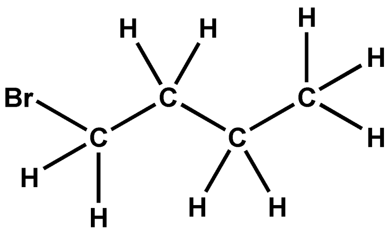
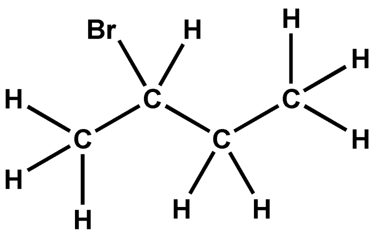
18c) Most students performed well, but some needed to be more explicit in their explanations, clearly stating which combinations will form a precipitate and which will not.

18d) Students should be explicit when suggesting methods for tests, detailing the procedure or observations required rather than giving vague or general answers.

Question	Answer	Marking Details
19a)	Electrical conduction requires freely moving charged particles through mediums Electrons cannot flow between molecules of Buckminsterfullerene	1 mark 1 mark
19b)	Buckminsterfullerene has strong covalent bonds They require large energy to overcome covalent bonds OR does not readily react.	1 mark 1 mark

Comments for Question 19

Most students were able to gain some marks on this question but overall, it was challenging given its niche status within the course. It was encouraging to see that many students attempted to answer this question.

Question	Answer	Marking Details
20a)	Contains a double or triple C-C bond.	1 mark
20b)		1 mark (-0.5 for missing hydrogens)
20c)	Decolouration of the brown Bromine solution to colourless.	1 mark
20d)	Isomer 1  Isomer 2 	1 mark per isomer (-0.5 for missing hydrogens)
20e)	Substitution reaction.	1 mark
20f)	$C_4H_{8(g)} + 2O_{2(g)} \rightarrow 4C_{(s)} + 4H_2O_{(g)}$	Many solutions available here 1 mark for correct products 1 mark for balanced No marks were deducted for missing states

Comments for Question 20

Overall, this question was well done; however, it is worth noting that a significant number of students left this question blank.

20 (a & b) Well answered.

20c) Students should remember to provide observations both before and after performing the test.

20d) Many students could identify only one isomer instead of two. It was also common for students to draw a structure that did not contain a four-carbon chain.

20f) Students should be reminded that “limited” combustion refers to incomplete combustion, so carbon dioxide should not be considered the only carbon-containing product.

Section E – Criterion 8

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General Comments for Criterion 8

Overall, students were able to engage with this section as the questions were quite structured and scaffolded. However, there is evidence that there is a lack of understanding regarding acid-bases, particularly when it requires a justification in the answer. Additionally, there also appears to be a lack of understanding on how to use the mole ratio in a balanced equation and the transposing of equations from the information sheet.

Students are also reminded that when completing 'show that' questions, they are expected to provide adequate working out and working backwards using the value provided is not an acceptable method.

Many students displayed a lack of proficiency in both the identification and consistent application of significant figures while problem solving.

</td></tr>
<tr><th>Question</th><th>Answer</th><th>Marking Details</th></tr>
<tr><td>21a)</td><td>$n(HNO_3) = c \times V = 8.10 \times 0.145$
$= 1.17 \text{ mol}$</td><td>1 mark
- 0.5 mark if mL used instead L</td></tr>
<tr><td>21b)</td><td>$6:2$ ratio (or $3:1$)
$n(Cr) = \frac{1}{3} \times 0.17 = 0.390 \text{ moles}$</td><td>0.5 mark for ratio
0.5 mark for calculation
- 0.5 mark deducted if 1.20 moles used from a) when the correct value was calculated</td></tr>
<tr><td>21c)</td><td>$m(Cr) = n \times M = 0.390 \times 52.00 = 20.3 \text{ g}$</td><td>0.5 mark for molar mass
0.5 mark for calculation</td></tr>
<tr><td>21d)</td><td>It is donating a proton (H^+or hydrogen ion)</td><td>1 mark</td></tr>
<tr><td colspan="3">

Comments for Question 21

Most of the errors in this question came from calculation, rounding and incorrect significant figures with error carried forward being applied. Students are reminded that in 'show that' questions appropriate working out must be shown, and students should not work backwards using the 'show that' value. Students need to be reminded that if an appropriate value is not calculated in a) they should use the 'show that' value in the following parts.

21a) Well answered by most students with the most common error not converting the volume from mL to L. An accurate value must be presented before stating that this was approximately the 'show that' value provided.

21b) Students commonly inverted the mole ratio, multiplying by three (3) instead of dividing, or used the 'show that' value of 1.20 instead of the value calculated in a).

21c) Many students used the coefficient from the reaction and multiplied the molar mass by 2 which doubled the mass answer.

21d) Most students identified that a proton was donated but confusion occurred with many students trying to explain where the proton was donated to. Multiple relevant answers were accepted as the reaction was not an acid-base reaction.

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</table>

<table>
<tr><th>Question</th><th>Answer</th><th>Marking Details</th></tr>
<tr><td>22a)</td><td>$M(C_{187}H_{291}N_{45}O_{59})$
$= (12.01 \times 187) + (1.008 + 291) + (14.01 \times 45) + (16.00 \times 59)$
$= 4113.648 \text{ g mol}^{-1}$
$= 4113.6 \text{ g mol}^{-1}$</td><td>1 mark for correct answer
- 0.5 mark if accurate molar mass values form information sheet were not used
- 0.5 mark if answer given was not approximate molar mass stated to ‘show that’ value</td></tr>
<tr><td>22b)</td><td>$n(C_{187}H_{291}N_{45}O_{59}) = \frac{m}{M} = \frac{1000}{4113.6}$
$= 0.243 \text{ mol}$</td><td>1 mark for correct answer
- 0.5 mark for each error</td></tr>
<tr><td>22c)</td><td>$N(\text{N atoms}) = 45 \times n \times N_A$
$= 45 \times 0.243 \times 6.02 \times 10^{23}$
$= 6.58 \times 10^{24} \text{ atoms}$</td><td>1 mark for $n \times N_A$
1 mark for $\times$ 45</td></tr>
<tr><td>22d)</td><td><table>
<tr><th></th><th>C</th><th>H</th><th>N</th></tr>
<tr><td>mass (g)</td><td>84.48</td><td>10.13</td><td>9.388</td></tr>
<tr><td>moles</td><td>$\frac{80.48}{12.01}$
= 6.7011</td><td>$\frac{10.13}{1.008}$
= 10.0496</td><td>$\frac{9.388}{14.01}$
= 0.6701</td></tr>
<tr><td>mol ratio</td><td>$\frac{6.7011}{0.6701}$
= 10.00</td><td>$\frac{10.0496}{0.6701}$
= 15.00</td><td>$\frac{0.6701}{0.6701}$
1</td></tr>
<tr><td>Final</td><td>10</td><td>15</td><td>1</td></tr>
</table>
$\therefore$ empirical formula $= C_{10}H_{15}N$</td><td>0.5 mark for mass
0.5 mark for mole calculation
1 mark for ratio calculation
0.5 mark for final ratio
0.5 mark for empirical formula</td></tr>
</table>

Comments for Question 22

Most of the errors in this question came from calculation, rounding, and incorrect significant figures with error carried forward being applied. Students are reminded that in 'show that' questions appropriate working out must be shown, and students should not work backwards using the 'show that' value. Students need to be reminded that if an appropriate value is not calculated in a) they should use the 'show that' value in the following parts.

22a) Well answered by most students. The most common errors were not using the molar mass values from the information sheet and not showing the exact calculated value before rounding to the 'show that' value in the question.

22b) Well answered. Common error was not converting mass from kilograms to grams.

22c) Most students received 1 mark. They identified that they needed to use Avogadro's number to calculate the number of molecules and could apply the appropriate equation but lacked the understanding that the equation needed to be multiplied by 45 to go from number of molecules to number of N atoms.

22d) Most students only received partial marks with few receiving full marks. Incorrect significant figure use led to most errors with incorrect simplest ratio being calculated. Some students incorrectly divided the molar mass by the given values. Many students did not clearly demonstrate the logic of their working out, which mark allocation required.

Question	Answer	Marking Details
23a)	Can donate two protons ($\mathrm{H^+}$)	0.5 mark for two protons 0.5 mark for donated (or similar) included
23b)	$\mathrm{Na_2CO_{3(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + H_20_{(l)} + CO_{2(g)}}$	0.5 mark deducted for each error
23c)	$\mathrm{2NaHCO_{3(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_20_{(l)} + 2CO_{2(g)}}$	0.5 mark deducted for each error
23 d)i	$\mathrm{n(Na_2CO_3)} = \frac{\mathrm{m}}{\mathrm{M}}$ $= \frac{100}{(2 \times 22.99) + 12.01 + (3 \times 16.00)}$ $= 0.943 \text{ mol}$	0.5 mark for molar mass calculation 0.5 mark for moles calculation
23 d)ii	$\mathrm{n(NaHCO_3)} = \frac{\mathrm{m}}{\mathrm{M}}$ $= \frac{100}{22.99 + 1.008 + 12.01 + (3 \times 16.00)}$ $= 1.19 \text{ mol}$	0.5 mark for molar mass calculation 0.5 mark for moles calculation

23 d)iii	From b) and c) and d) I and ii. Na_2CO_3 (1:1) ratio – produced 0.943 mol CO_2 $NaHCO_3$ (2:2 or 1:1 ratio) – produced 1.19 mol CO_2 $n(CO_2 \text{ produced by } NaHCO_3) > n(CO_2 \text{ produced by} Na_2CO_3)$ $\therefore$ $NaHCO_3$ produces more CO_2	0.5 if just writes formula with no reasoning 1 mark for reasoning 1 mark for a statement
23 d)iv	From b) and c) and d) I and ii. 100 g of Na_2CO_3 (1:1) ratio – will neutralise 0.943 mol H_2SO_4 100 g of $NaHCO_3$ (2:1) ratio – will neutralise $\frac{1.19}{2} = 0.595$ mol H_2SO_4 $\therefore$ Na_2CO_3 will be better at neutralising.	0.5 if just writes formula with no reasoning 1 mark for reasoning 1 mark statement
23e)	Not as effective. The molecular mass of $Na_2CO_3.10H_2O$ is much larger, meaning there is less moles for a given mass.	0.5 if just writes yes with no reasoning 1 mark for reasoning 1 mark for statement

Comments for Question 23

Question 23 was poorly answered by most students, and a considerable number left it unanswered. There is a general lack of understanding of how to apply a balanced equation and the mole ratio to determine the moles of other reactants/products. Most of the common errors came from calculation, rounding and incorrect significant figures with error carried forward being applied.

23a) Poorly answered. Many students associated protic with H being present, not H^+ being donated. There is a lack of understanding of the term diprotic.

23b) Majority of students attempted the question with most receiving no marks. The ionic equations 1 and 2 provided were confusing as students struggled to produce a correct balanced equation. Students should be using their Information Sheet to guide them to the correct products for the acid-base reactions. Many students could not provide the correct formula for sulfuric acid and failed to identify the solid state of one of the reactants. Many students also labelled water as 'aqueous'.

23c) As above for 22c).

23d)i Generally well answered.

23d)ii Generally well answered. A common error was many students added molar mass of hydrogen to i) to calculate molar mass of sodium hydrogen carbonate. Many students also used N instead of Na.

23d)iii Poorly answered with most students stating one of the two options with no justification. Students needed to correctly refer to equations in b) and c) and use the mole ratio to determine the moles of CO_2 produced. Many students did not realise that in equation b) and c) 1:1 is the same as 2:2 ratio.

23d)iv Poorly answered with most students stating one of the two options with no justification. Students needed to correctly refer to equations in b) and c) and use the mole ratio to determine the moles of H_2SO_4 produced.

23d)v Very poorly answered. Many students referred to strength of base and availability of H. Students did not understand that the hydrated compound was a solid and that the same mass (100 g) would produce less mol/L of the base due to the larger molar mass. Most stated that the solution would be more dilute due to the water in the hydrated compound and therefore less efficient. Overall, there is confusion about dilution and neutralisation, which needs addressing.

Question	Answer	Marking Details
24a)	$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$	0.5 mark deducted for each error
24b)	$n(NaOH) = c \times V$ $= 0.0852 \times 0.025 = 2.13 \times 10^{-3}$ mol	0.5 mark deducted for each error
24c)	$n(HCl) = n(NaOH)$ (1:1 ratio) $n(HCl) = 2.13 \times 10^{-3}$ mol	0.5 mark deducted for each error
24d)	$c(HCl) = \frac{n}{V} = \frac{2.13 \times 10^{3}}{0.0121} = 0.176\ mol\ L^{-1}$	0.5 mark deducted for each error
24e)	$HCl\ (g\ L^{-1}) = c \times M = 0.176 \times (1.008 + 35.45)$ $= 6.42\ g\ L^{-1}$ **OR** $m(HCl) = n \times M = 0.00123 \times (1.008 + 35.45)$ $= 0.0777\ g$ $HCl\ (g\ L^{-1}) = \frac{g}{L} = \frac{0.0777}{0.0121} = 6.42\ g\ L^{-1}$	0.5 mark deducted for each error
24f)	dilute = low concentration. i.e. low number of moles per litre Strong = Fully dissociates into its constituents (H^+ and Cl^-)	1 mark for definition of dilute 1 mark definition of strong
24g)	pH = 1-2	1 mark 0.5 mark if pH 3 given

Comments for Question 24

Most of the errors in this question came from calculation, rounding, and incorrect significant figures with error carried forward being applied.

24a) Generally well answered. Balanced equation was better handled than Question 23. Most common error was not including states of matter, or incorrectly stating states of matter, for example NaCl as a solid and water as aqueous.

24b) Generally well answered. Common errors included incorrect transposition of equation, not converting mL to L, and no units in answer.

24c) Most students only received partial marks with few receiving full marks. Many students failed to justify response with a mole ratio.

24d) Generally well answered. Most frequent error was students using the incorrect volume of solution, 25.0 mL instead of 12.1 mL. Other common errors included rounding and incorrect insignificant figures.

24e) Poorly answered. Most students incorrectly divided by the molar mass instead of multiplying. Students also incorrectly used the value from c) in the question rather than d).

24f) Generally well answered with most students receiving partial marks with few receiving full marks. Most students recognised dissociation regarding 'strong' but failed to appropriately explain 'dilute'. There is confusion amongst terminology with many students using the term 'highly ionising'.

24g) Not well answered. Many were left unanswered or wrote a pH range. Many students appeared to not make the connection between f) and g) regarding stomach acid.

Question	Answer	Marking Details
25a)	$5.000 - 3.191 = 1.809\ \mathrm{g}$	0.5 mark deducted for each error
25b)	$n(CO_2) = \frac{m}{M}$ $= \frac{1.809}{44.01}$ $= 0.04110\ \mathrm{mol}$ $n(CaCO_3) = n(CO_2)$ (1:1 ratio) $n(CaCO_3) = 0.04110\ \mathrm{mol}$ $m(CaCO_3) = n \times M$ $= 0.04110 \times 100.1$ $= 4.114\ \mathrm{g}$	1 mark mole calculation CO_2 1 mark mole calculation $CaCO_3$ 1 mark mass calculation $CaCO_3$
25c)	$\%(CaCO_3) = \frac{4.114}{5.000} \times 100 = 82.23\%$	0.5 mark deducted for each error

Comments for Question 25

Question 25 was poorly answered by most students, and a considerable number left it unanswered. Errors in this question came from calculation, rounding, and incorrect significant figures, with error carried forward being applied. Many students failed to realise that the original sample before heating was a mixture of calcium carbonate and calcium oxide.

25a) Generally well answered.

25b) Poorly answered. Majority of students did not use the mass from a) to calculate the number of moles of CO_2, and then the mole ratio to calculate the mass of $CaCO_3$. Students who attempted the question consistently used 5.000 g in their calculations.

25c) Generally well answered with most errors coming from significant figures.