2022 ASSESSMENT REPORT
PSC315118 – PHYSICAL SCIENCES

The 2022 exam represented the course well and the majority of students were well-prepared. Award rating cut-off points for each part are shown below.

Award \ Criterion	4	5	6	7	8
A	29	31.5	31	30	32
B	24	25.5	25	23	25
C	15	15	11	13.5	14

The marking scheme follows with specific comments on student performance on each question.

Part A
Criterion 4

QUESTION 1

Question	Answer	Mark Allocation	Comment
Q1a	White nucleon = neutron Black nucleon = proton Cross = electron	2	½ for one correct label Two correct = 1 mark All correct = 2 marks

Question	Answer	Mark Allocation	Comment
Q1b	Li^+ has a full valence shell / outer shell	1	
Q1c	Boron All are in the same period and have the same number of occupied electron shells. (or the valence shell is the same shell number) B has the highest nuclear charge and greatest force of attraction holding the valence electrons	1 1 1	-½ for missing "occupied" -½ for attributing greater force of attraction to increased number of electrons rather than protons
Q1d	2,2	1	

COMMENTS FOR QUESTION 1

Well answered. Common errors/omissions:

1 b) Since the inner shell only contains 2 electrons the "octet rule" does not apply.

1 c) Electrostatic (**not** *electromagnetic or gravitational*) force of attraction between electrons and nucleus is driven by increasing effective nuclear charge (number of protons), not electrons. It is advisable to avoid electronegativity as a rationale for atomic radius.

1 c) Common omission was the fact that all atoms cited had the same number of occupied electron shells.

QUESTION 2

Question	Answer	Mark Allocation	Comment
Q2a	T1/2 = 22–24 minutes	2	Graph annotations or points used must be shown for full marks Points used should be on LOBF; if not –½ mark
Q2b	Random nature of radioactivity (or similar wording)	1	½ mark for the alternative answers of background radiation or for equipment
Q2c	It is produced as the daughter isotope in other decay chains, or other similar wording	1	
Q2d	$^{223}_{87}Fr \rightarrow \ ^{0}_{-1}e \ + \ ^{223}_{88}Ra$	2	Max of 1 if electron capture is shown instead on beta minus decay If gamma is shown –½ mark Must use normal equation symbols (arrows, plus sign, etc)

COMMENTS FOR QUESTION 2

Well answered, with responses to part a) the most disappointing. Common errors/omissions:

2 a) It is important that with decay curves, points selected to determine the half-life are on the line of best fit. Carefully drawn (using a ruler) construction lines are also excellent to help show working. Ensure to show an appropriate level of accuracy when reading a graph. The provided graph does not start at 110 or 115, as suggested by many students.

2 b) A number of students struggled with the term "account for".

2 c) Using general terms such as "created" or "made" should be avoided; Fr–223 is the product of decay processes resulting in a fairly constant level of it in the earth's crust.

2 d) Quite a few students incorrectly put gamma in their equation as a product. The gamma decay process, where excited daughter nuclei can become more stable, usually occurs **after** (beta) decay.

QUESTION 3

Question	Answer	Mark Allocation	Comment
Q3a	$^{223}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{219}_{86}Rn$	2	No penalty for gamma
Q3b	$^{188}_{75}Re \rightarrow {}^{0}_{-1}e + {}^{188}_{76}Os$	2	Max of 1 if electron capture (forming Ir) is shown but conservation of mass number and charge number is correct
Q3c	<u>Alpha:</u> Highly ionising, poorly penetrating. Kills tumour cells effectively but only over a very short range, so unlikely to kill large tumours. <u>Beta:</u> Less ionising, more penetrating. Less effective at killing cancer cells but will kill to greater depth, meaning it may be effective with large tumours.	 1 1 1 1	2 marks allocated to the ionising and penetrating ability of alpha and beta. 2 marks allocated to advantages of each method.
Q3d	Radioisotopes in the body will kill/mutate health normal cells (via ionisation).	1	

Question	Answer	Mark Allocation	Comment
Q3e	Gamma is highly penetrating Gamma can be detected outside the body so it can be used to locate tumours or isotope accumulation locations.	1 1	

COMMENTS FOR Q3

A more challenging question as most students missed the important point mentioned in the stem of the question – that the radioisotopes are injected into the body and not directed from outside.

Common errors/omissions:

3 a) The most unlikely scenario of capture of an alpha nucleus by radium was not uncommon.

3 b) Commonly misread: A common error was not reading the key word **formation** in the question; a significant number of students wrote a nuclear decay equation for the beta decay of Os–188

3 c) Many responses adequately described the properties of alpha and beta radiation but failed to connect these properties to their advantages in treatment (once they had been injected into the patient).

3 d) The fact that alpha and beta radiation are ionising was often omitted with general statements made about radiation damaging organs etc.

3 e) In the question, gamma is emitted from a source already inside the body; some responses discussed the use of gamma being directed from outside into the patient.

QUESTION 4

Question	Answer	Mark Allocation	Comment
Q4a	$^{91}_{36}Kr$	1	

Question	Answer	Mark Allocation	Comment
Q4b	The neutrons produced from one fission reaction start more reactions.	1	Neutrons must be discussed in order to gain marks
Q4c	20.0 kBq	3	Part marks for incorrect answers as long as working shown
Q4d	5.12 MBq	1	½ for increasing activity ½ for correct number of half-lives
Q4e	Cosmic Rocks Anything sensible	1	Must have two sources to gain the mark.

COMMENTS FOR Q4

Again, well answered, with 6 or 7/7 obtained by many students. Common errors/omissions:

4 a) The most common mistake was not factoring in the contribution of the 3 neutrons to the total mass number – many responses provided $^{93}_{36}Kr$ instead of $^{91}_{36}Kr$.

4 e) Mobile phones, radiowaves do not contribute to (ionising) background radiation.

QUESTION 5

Question	Answer	Mark Allocation	Comment
Q5a	$\frac{5.888 \times 10^{-23}}{1.993 \times 10^{-23}} \times 12$ or $\frac{5.888 \times 10^{-23}}{\frac{1}{12} \times 1.993 \times 10^{-23}}$	2	Max of 1 mark if simply multiplying 5.888×10^{-23} by N_A 1 mark for fraction 1 mark for x 12 No marks for just providing the answer.
Q5b	$\left(\frac{x}{100} \times 35\right) + \left(\frac{100 - x}{100} \times 37\right) = 35.45$ $0.35x + 37 - 0.37x = 35.45$ $0.02x = 1.55$ $x = 77.5$ $\therefore$ Cl–35 = 77.5%, Cl–37 = 22.5%	1 1 1	Max of 1 mark for correct answer with no obvious working

COMMENTS FOR Q5

Question 5 contained straightforward, predictable questions, but, surprisingly, challenged students.

Many students were unable to answer these questions. Common errors/omissions:

Steps taken, in both a) and b), were poorly communicated.
As per the instructions on the first page of each booklet in the exam, for full marks to be allocated, working should be shown.

Part B
Criterion 5

QUESTION 6

Question	Answer	Mark Allocation	Comment
Q6a	178 km	1	
Q6b	$\sqrt{78^2 + 100^2}$ = 127 km θ = arctan(100/78) = 52o S = 127 km, N52°W	1 1 1	0.5 marks was awarded for a statement of displacement giving 127km, N52°W was required for full marks
Q6c	$v_{average} = \frac{S}{t} = \frac{127}{0.5} = 254\ km/hr\ \ S52^oE$	2	1 mark for magnitude 1 mark for direction

COMMENTS FOR QUESTION 6

This question was generally well answered with most students gaining full marks for part a). Errors included:

6 b) Some students did not attempt to calculate direction, and some did not correctly calculate the angle or did not correctly convert it to a direction.

6 c) Magnitude calculations were mostly correct, **but** some divided by 30, not realising their units would be km/minute. A number of students missed the direction or assumed the velocity on the return trip would have the same direction as that of the displacement in part b. Part marks were awarded for the latter error.

Students who answered in m/s were given credit, but some multiplied by 100 rather than 1000 to convert to metres and some students' final response incorrectly gave directions as an angle below horizontal rather than a bearing.

QUESTION 7

Question	Answer	Mark Allocation	Comment
Q7a	$\text{Speed} = \frac{\text{dist}}{\text{time}} = \frac{15}{0.632} = 23.7 \text{ km/hr}$	1	
Q7b	23.7 ¸ 3.6 = 6.59 m/s	1	
Q7c	80 – 100 seconds	1	Velocity of zero at the start was not required for full marks
Q7d	Area $= \left(\frac{1}{2} \text{ x } 50 \text{ x } 5\right) + (30 \text{ x } 5) + \left(\frac{1}{2} \text{ x } 20 \text{ x } 4\right) + (40 \text{ x } 4)$ = 475 m	1 1	1 mark given for attempting to use the area under the graph when answers other than 475 m were calculated
Q7e	Slope $= \frac{\text{rise}}{\text{run}} = \frac{5}{50} = 0.10 \text{ m/s North.}$	1	No penalty for omitting direction.

COMMENTS FOR QUESTION 7

Very well done. Errors included:

7 a) Some students were penalised for significant figures when they gave a large number of decimal places.

7 b) Some students multiplied by 3.6 rather than dividing to convert to m/s.

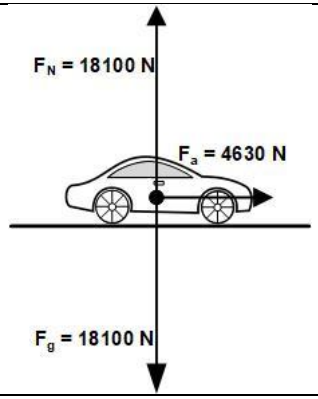
7 c) Some students stated that the skier was stationary whenever they had constant velocity.

7 d) Most students knew to use the area under the graph, but some did not section it to make the calculations easy and some struggled to read the scale correctly. Some credit was given for use of the strategy. The use of the area of a trapezium rather than rectangles and triangles made it more challenging to calculate the correct answer. Using equations of motion with values taken from the graph generally resulted in an incorrect answer and zero marks.

7 e) Some students used run/rise giving a = 10m/s^2. Some students used 5/40 and forgot units. Suggest reading graphs carefully.

QUESTION 8

Question	Answer	Mark Allocation	Comment
Q8a	v = u + at v = 10 + (2.5 x 10) = 35 m/s North	2	1.5 max if no direction given
Q8b	s = ut + ½ at^2 s = (10 x 10) + ½ (2.5 x 10^2) s = 225 m North	2	1.5 max if no direction given
Q8c	F = mg = 1850 x 9.81 = 18100 N (down)	1	No penalty for omitting down No credit given if 2.5 m/s was used

Q8d		3	0.5 marks were awarded for each arrow 0.5 marks for Fn and Fg having equal lengths 0.5 marks for calculating Fa 0.5 marks for the Fa arrow being shorter
Q8e	N1 According to N1, the driver will maintain her current motion until an unbalanced force acts on her. During acceleration the car seat applies an unbalanced force forward which feels like she is being pushed back.	1 1	For 1 mark here students were required to describe the law. Credit was occasionally given for alternate laws (NL2 explaining the unbalanced force or rarely NL3), if the explanation of their effect on the driver was correct.

COMMENTS FOR QUESTION 8

Appropriate equations were mostly used but labelling the forces was rarely done well. Errors included:

8 a) and 8 b) Many students missed directions.

8 c) Many students lost half a mark for giving 6 significant figures.

8 d) As the question did not explicitly ask for the value of each force, magnitudes were rarely given in student responses. Many students failed to begin their vector arrows at the centre of mass dot in the diagram. Most had similar lengths for Fn and Fg but marking to signify their equality was rare. Scaling of Fa to be approximately ¼ of the length of Fg was similarly rare so 0.5 was awarded if Fa was shorter than Fg.

8 e) Some students recognised the effect of inertia in this question but did not state Newton's first law. Credit was given if they correctly described the effect on the driver as she accelerated. Others tried to relate the unbalanced force to NL2, which gained credit if their

explanation made sense. Many students used NL3, mostly describing the law well but going on to make statements about unrelated forces during the car's acceleration being equal and opposite.

QUESTION 9

Question	Answer	Mark Allocation	Comment
Q9a	$v^2 = u^2 + 2as$ $\therefore s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 24.8^2}{2 \times 9.81}$ $\therefore s = 31.3$ m $\therefore$ max height = 31.3 + 1.60 = 32.9 m	1.5 0.5	
Q9b	Time to travel up $v = u + at$ $t = t = \frac{v-u}{a} = \frac{0 - 24.8}{-9.81} = 2.53$ sec Time to travel down $s = ut + \frac{1}{2} at^2$ $32.9 = 0 + \frac{1}{2} \times 9.81 \times t^2$ $\therefore t = \sqrt{\frac{32.9 \times 2}{9.81}}$ $\therefore t = 2.59$ sec Total time = 2.59 + 2.53 = 5.12 sec	1 1.5 0.5	errors carried forward from a) were not penalised
Q9c	When $F_g = -F_f$ Zero acceleration when the accelerating force is balanced by frictional force.	1	0.5 marks was given for zero acceleration or maximum velocity

Question	Answer	Mark Allocation	Comment
			0.5 marks given for balanced forces of weight and air resistance
Q9d	Fg of the light ball is small and so it requires a small frictional force to balance it. This small frictional force is achieved at a slow speed. Or The light ball has a large surface area to mass ratio meaning it is more affected by air resistance at low speed. Or similar!	1	No credit was given for responses that only mentioned the ball having less mass or weight.

COMMENTS FOR QUESTION 9

Reasonably to very well done. Errors included:

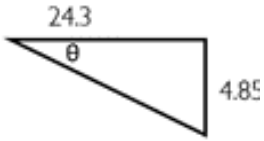
9a) Some students forgot to square their value for u when using $v^2 = u^2 + 2as$ so they got a very small value for the maximum height. A few forgot to add 1.6 m to their calculation.

9b) Of the errors, most were only calculating the time to the top of the flight, and some students simply doubled the time to go up, not realising the time to fall down to be different. Some credit was given when this was done and a separate time to fall 1.6 m was added.

9c) Most students recognised that there was no further acceleration but succinctly describing the opposing forces that produced a net force of zero was more challenging.

9d) This part was not well done. Students who used forces to explain the differences between the rock and ball's flights did a better job of accounting for the shorter time to Fnet = 0.

QUESTION 10

Question	Answer	Mark Allocation	Comment
Q10a	$s = ut + \frac{1}{2}at^2$ $1.2 = 0 + \frac{1}{2} \times 9.81 \times t^2$ $t = \sqrt{\frac{1.2}{4.905}}$ $t = 0.495$ sec	1 1	
Q10b	$s = ut + \frac{1}{2}at^2$ $12 = u \times 0.495$ $\therefore u = 24.3 \text{ m s}^{-1}$	1 1	
Q10c	$v = u + at$ $v = 0 + 9.81 \times 0.495$ $\therefore v = 4.85 \text{ m s}^{-1}$ $c^2 = a^2 + b^2$ $\therefore v = \sqrt{24.3^2 + 4.85^2}$ $\therefore v = 24.8 \text{ m s}^{-1}$ $\theta = \arctan\left(\frac{4.85}{24.3}\right) = 11.3°$ Velocity = 24.8 m s^{-1} 11.3° below horizontal 	1 1 1	A statement summarising velocity was required for full marks

COMMENTS FOR QUESTION 10

When attempted, this question was reasonably well done. Errors included:

10 a) Some students forgot to subtract 0.9 m from the vertical distance travelled so had a longer time. While most recognised $u_{vertical}$ as zero, some students were unable to transpose the equation correctly and some claimed that their calculations gave t = 0.5 when it did not.

10 b) Most students were able to calculate the horizontal velocity correctly, but some included acceleration of 9.81 m s^{-2}.

10 c) A number of students did not understand the need to do a vector sum to calculate the final velocity, rather skipped this question or tried to substitute horizontal and vertical motion values into a single equation.

Part C

Criterion 6

QUESTION 11

Question	Answer	Mark Allocation	Comment
Q11a	$E_p = mgh$ $E_p = 74.5 \times 9.81 \times 32.1$ $E_p = 23460$ J $E_p = 23500$ J (3 s.f.)	1 1	
Q11b	$E_k = 23500$ J	1	
Q11c	$E_k = ½\ mv^2$ $E_k = ½ \times 74.5 \times 18.0^2$ $E_k = 12070$ J W = ΔE = 23460 – 12070 = 11390 J W = 11400 J (3 s.f)	1 1	

Question	Answer	Mark Allocation	Comment
Q11d	W = Fs $F = \frac{W}{S} = \frac{11390}{145} = 78.6$ N (3 s.f)	1	

COMMENTS FOR QUESTION 11

Generally well done by all students, although use of correct significant figures is a concern. While not penalised unduly, it needs to be considered.

Errors included:

11 c) Many students forgot to square the value for velocity – this was common throughout the section.

11 d) Generally poorly done with many leaving the question blank. A common error was to incorrectly substitute into the formula F = ma, with a = 9.81m s^{-2}.

Weak algebra skills hindered some students.

QUESTION 12

Question	Answer	Mark Allocation	Comment
Q12a	E_p = mgh $E_p = 1.8 \times 10^9 \times 9.81 \times 180$ $E_p = 3.2 \times 10^{12}$ J (2 s.f.)	1 1	
Q12b	% transfer $= \frac{1.43 \times 10^{12}}{3.18 \times 10^{12}}$ = 0.445 or 44.5% (3 s.f)	1	

Q12c	$P = \frac{\Delta E}{t}$ $P = \frac{1.43 \times 10^{12}}{24 \times 60 \times 60}$ $P = 1.7 \times 10^{7}$ W (2 s.f)	1 1	
Q12d	Ek from the wind is converted into electrical energy that powers the water pump that lifts the water into the dam creating E_p. The water stored in the dam drops, increasing its E_k,, which in turn drives a turbine that converts the energy into electrical energy. The water can then be lifted again by the energy from the wind turbine continuing the process. An alternative approach is a diagrammatic representation, provided it is 'understandable'.	Any linked 4 points gains 2 marks.	

COMMENTS FOR QUESTION 12

This was the most challenging question for students in this criterion. Many students left this question blank.

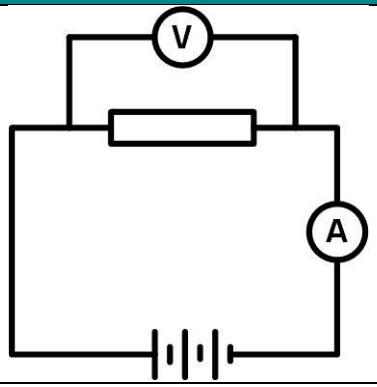
12 a) and b) were generally well done when attempted.

12 c) Commonly, students used an incorrect ΔE by using the difference between the theoretical energy (answer to part a) and actual electrical energy instead of only using the actual electrical energy 'created' (given in stem of question in part b). Some students failed to convert time to seconds.

12 d) Students struggled with this question. Very few gained the 2 marks available. Many students listed energy types, but failed to produce clear links between them. Some confused energy types with energy sources. Several students listed energy types that were not

relevant to the diagram (such as light and nuclear). Strong responses linked the energy transfers and transformations to specific regions in the diagram.

QUESTION 13

Question	Answer	Mark Allocation	Comment
Q13a		2	0.5 for each correct component. The "mains" supply symbol, copied from question c, was not accepted in the place of the battery
Q13b	i V = 1.5 V ii $I = \frac{V}{I} = \frac{1.5}{6.0}$ = 0.25 A	1 1	
Q13c	$R = \frac{V^2}{P} = \frac{240^2}{9}$ R = 6400 Ω (2 s.f.)	1	
Q13d	Total Power = 20 W ∴ Power (second globe) = 20 – 9 = 11 W $\therefore R = \frac{V^2}{P} = \frac{240^2}{11}$	1 1	

	∴ R = 5240 Ω ∴ R = 5200 Ω (2 s.f.) Alternative solution $R = \frac{V^2}{P} = \frac{240^2}{20} = 2880\ \Omega$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ Or $R_2 = \frac{R_1 R_T}{R_1 - R_T}$ $= \frac{6400\ X\ 2880}{6400 - 2880}$ = 5200 Ω	I I I I	
Q13e	20 W = 0.020 kW E = Pt = 0.020 x 24 = 0.480 kW Cost = 24.697 x 0.480 = 11.85 cents ≈ 12 cents (nearest cent)	I I	0.5 marks subtracted for not rounding to nearest cent
COMMENTS FOR QUESTION 13			

A lack of algebra skills hampered many students. Other errors included:

13 a) Whilst most students got the "wiring" correct, it was concerning that most students did not use the correct cell conventions. Many used the "mains" supply symbol, copied from question c in the place of a battery.

13 b) Done very well.

13 c) Generally done well. The most common mistake was thinking that I = 9 A, instead of using the circuit diagram to see that P = 9 W.

13 d) Many determined total resistance using 20 W and failed to complete the appropriate algebra to determine R_2 (2nd globe).

13 e) Many students failed to convert 20 W to 0.02 kW before calculating the cost, and also not multiplying by 24 to determine a value for time, instead multiplying by 24 x 60 x 60.

Many students lost ½ mark for not rounding to the nearest cent. Students are reminded to carefully read the question to see what is required.

QUESTION 14

Question	Answer	Mark Allocation	Comment
Q14a	90 – 93 mA	1	
Q14b	q = It $= 90 \times 10^{-3} \times 1$ $= 9.0 \times 10^{-2}$ C	1	
Q14c	Number of electrons = $\frac{9 \times 10^{-2}}{1.6 \times 10^{-19}}$	1	

	= 5.63 x 1017		
Q14d	Non-ohmic resistors do not have a constant resistance at all applied voltages. On the graph this is indicated as a non-linear graph.	 1	
Q14e	$V = IR$ $\therefore R = \frac{V}{I}$ ∴ resistance is highest when current is lowest, so the blue diode has the greatest resistance. (Actual values can be calculated, obtaining 22 Ω, 50 Ω and 200 Ω at 2 V for red, green and blue respectively.)	 1 1	

COMMENTS FOR QUESTION 14

Question 14 was generally well done. Errors included:

14 b) A very common mistake was multiplying 90 x 1 to get 90 C instead of 90 mC. Unit conversions are often overlooked by students.

14 c) Many students incorrectly multiplied by 1.6×10^{-19} instead of dividing. Some had a negative answer due to the negative charge on an electron.

14 d) This was answered very well.

14 e) Several students answered that the red diode had the highest resistance by referring to the slope of the graph. In a V~I graph with I on the y–axis, the slope is actually $\frac{1}{R}$. Perhaps this is being taught with the axes around the other way, students need to be made aware of the difference.

QUESTION 15

Question	Answer	Mark Allocation	Comment
Q15a	<u>Ball Carrier:</u> p = mv = 98 x 3.7 = 360 kg m s^{-1} north (2 s.f.) <u>Tackler:</u> p = mv = 84 x 4.8 = 400 kg m s^{-1} south (2 s.f.)	1 1	–/+ needed to be defined to be awarded marks.
Q15b	p(total) = –363 + 403 = 40.6 kg m s^{-1} south Since p = mv $\therefore v = \frac{p}{m} = \frac{40.6}{98+84}$ $\therefore$ v = 0.22 m s^{-1} south	1 1	
Q15c i	$E_k = mv^2 + \frac{1}{2}mv^2$		

	$E_k = (½ \times 98 \times 3.7^2) + (½ \times 84 \times 4.8^2)$ $E_k = 1638$ J $E_k = 1600$ J (2 s.f.)	1	
Q15c ii	$E_k = ½mv^2$ $E_k = ½ \times (98 + 84) \times 0.22^2$ $E_k = 4.4$ J	1	
Q15c iii	Not elastic. Since $\mathbf{E_k}$ is not conserved	1	"Energy (unqualified) was not conserved", was **not** accepted.

COMMENTS FOR QUESTION 15

Directions of vectors were frequently neglected. Other errors included:

15 a) Many students missed the direction in their answers.

15 b) Students commonly added momenta as two positive values, failing to recognise that vectors in different directions have opposite signs. Many students added/subtracted the initial velocities of carrier and tackler.

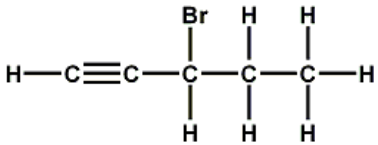
15 c i) Commonly students determined the individual energies, but did not add them together. A number of students added the velocities and used this in one E_k equation – algebra skills lacking.

15 c ii) A very common mistake was not squaring the velocity, either through not writing the equation correctly or not inputting it into the calculator correctly.

15 ciii) Poorly done. Many students have a misconception – referring to uncoupled reactions and "bouncing off" as elastic.

Part D
Criterion 7

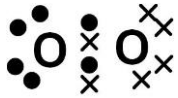
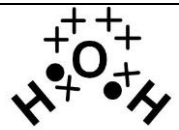
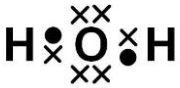
QUESTION 16

Question	Answer	Mark Allocation	Comment
Q16a	i Barium hydroxide ii Silicon dioxide	1 1	
Q16b	i $Fe_2(CO_3)_3$ ii $K_2Cr_2O_7$	1 1	0.5 mark subtracted for including ionic charges in formula 0.5 marks awarded for $K_2Cr_2O_4$
Q16c		1	
Q16d	1-chloro-2-methylcyclohexane	1	0.5 subtracted for use of cyclic rather than cyclo or for incorrect order of chloro & methyl
COMMENTS FOR QUESTION 16			

Question	Answer	Mark Allocation	Comment
16 ai)	Dihydroxide was a common error and was penalised, as was using the incorrect name for barium and the use of (II) in the name.		
16 aii)	The use of common names such as quartz was not awarded any marks.		
16 bi)	Common errors included incorrect subscripts and the use of (II) in the formula, keeping the ion charge and incorrectly balanced formulae.		
16 bii)	CrO_4^{2-} was too often used (instead of $Cr_2O_7^{2-}$), half a mark only deducted if K_2 was used correctly in the formula. No penalty for the use of brackets although these were not required.		
16c)	Generally done well although the omission of the –H on the end carbon attached to the triple bond was a common error. The numbering of the carbons in the chain was not penalised but is discouraged. Condensed formula was not awarded any marks. Students also used 'ene' instead of 'yne', multiple bromines and lowercase 'br'.		
16 d)	Poorly done overall. Alphabetical naming of the side chains/substitutes was expected, i.e., 1-chloro- 2-methyl rather than 2-chloro-1-methyl; the word cyclic was not awarded marks.		

QUESTION 17

Question	Answer	Mark Allocation	Comment
Q17a	Oxygen	1	
Q17b	Fluorine and chlorine	1	
Q17c	Fluorine and chlorine	1	
Q17d	Hydrogen	1	
Q17e		1	

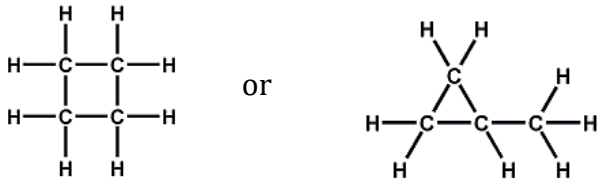
Question	Answer	Mark Allocation	Comment
		1	
	 or 	1	
Q17f	Melting point is dictated by the strength of the intermolecular forces between molecules; i.e., strong IM forces means high MP. Diagram showing polarity H_2 and O_2 have have very weak IM foces as they are non-polar H_2O is a highly polar covalent molecule and has strong IM forces	0.5 0.5 1 1	

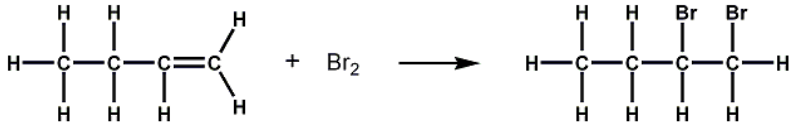
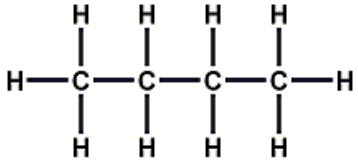
COMMENTS FOR QUESTION 17

Students are encouraged to use specific chemistry language with precise terms and concise statements, avoiding "data dumps" when asked to explain properties and differences. When differences are involved, discuss all the chemicals or properties as they are compared. It is important to be able to differentiate between electron dot diagrams and electron shell diagrams and to draw each correctly.

Question	Answer	Mark Allocation	Comment
17 a)	Cl_2 often mentioned due to it being in the same period, but this was not awarded any marks.		
17 b)	Generally done well but the addition or omission of extra elements resulted in a deduction of marks. Students sometimes named a period rather than elements as required.		
17 c)	Generally done well. Addition of hydrogen was accepted, but not required.		
17 d)	Generally done well.		
17e)	Examiners were looking for a clear pairing of electrons and lone pairs needed to be included. The use of circles around the bonding pairs is discouraged – a note for future teachers.		
17 f)	Examiners were looking for reference to polar/non-polar molecules and the subsequent strong/weak bonds with a link to melting and/or boiling point to fully answer the question. A diagram showing the dipoles was expected for full marks. A comparison between water and H_2/O_2 was also required for full marks.		

QUESTION 18

Question	Answer	Mark Allocation	Comment
Q18a	Alkene	1	
Q18b	Structure of cyclobutene or methylcyclopropane 	1	

Q18c		2	
Q18d	$C_4H_{8(g)} + 5O_{2(g)} \rightarrow C_{(s)} + CO_{2(g)} + 4H_2O_{(g)}$	2	1 for correct products and reactants. 1 for balance and most states. Other balanced equations with a combination of C, CO and CO_2 accepted.
Q18e	(i) Butane structure  (ii) F_2	1 1	

COMMENTS FOR QUESTION 18

18 a) The term homologous was obviously not well known, with the expected answer of alkenes not used in many cases.

18 b) Similarly, some confusion with the meaning of 'saturated' and/or 'isomer' was evident with many unsaturated examples being submitted or, alternatively, many saturated diagrams without the expected C_4H_8 formula.

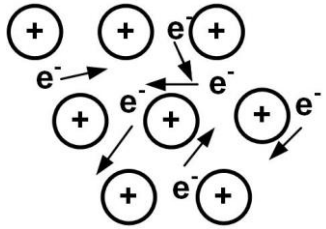
18 c) Not well done overall with many unable to show the double bond breaking and the Br_2 adding across successfully. Condensed formulas were often used, but not accepted.

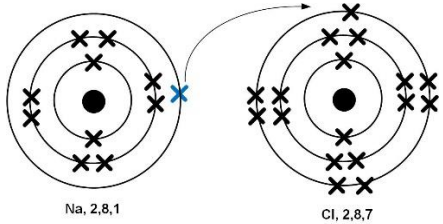
18 d) Several correctly balanced equations were possible. Complete combustion equations were not accepted. H_2O as a liquid was also accepted although the preference is for this to be a gas. Attempts at balancing and providing states were expected. Butene had to be

indicated as gas, as stated in question. Some students seemed to have read the question incorrectly, answering as if there was "sufficient oxygen".

18 e) Reasonably well done. Reaction conditions for (ii) should have UV light, but this was not required for full marks.

QUESTION 19

Question	Answer	Mark Allocation	Comment
Q19a	 Diagram indicates cations surrounded by a sea of delocalised electrons (SDE).	1	
	This creates non-directional bonds between the cations and the SDE allowing atoms/layers to move past each other without disrupting the force between atoms/layers.	1	
	The delocalised electrons can move and so conduct. If the metal is deformed non-directional forces between delocalised electrons and the cation lattice hold the lattice together.	1	

Q19b	 The Na loses an electron to become Na^+ Cl gains and electron to become Cl^- Both ions have a full valence shell The ions attract electrostatically forming an ionic lattice	1 1 1	The diagram can be used to indicate the first two marks in this problem.
Q19c	i Add silver nitrate / $AgNO_3$). A precipitate will form $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$	2	
	ii Flame test	1	

COMMENTS FOR QUESTION 19

Not generally well done.

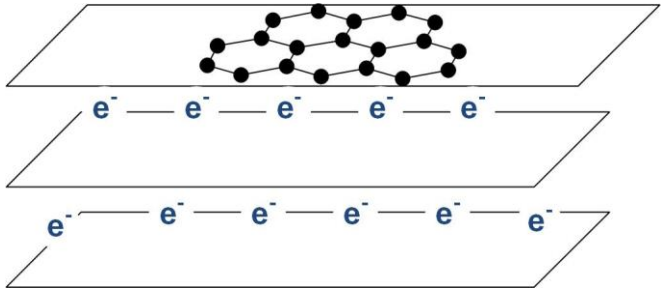
19 a) A labelled diagram with explanation, as well as a clear worded explanation of how the named properties resulted was expected. Simply stating that there are delocalised electrons does not explain properties. Many responses did not fully explain the reason why metals were malleable (non-directional electrostatic forces preventing cation–cation repulsion).

19 b) Some responses demonstrated confusion over ionic bonding with many examples of shared electrons submitted. Similarly, students stated that ions lose/gain electrons, rather than atoms; i.e., Some referred to Na^+ ions losing electrons rather than Na atoms losing electrons to become Na^+ ions. The electron shell diagram needed to show all shells and the transfer of the electron for full marks. Few students showed this transfer or referred to the electrostatic attraction between the cation and anion.

19 ci) Reasonably well done although too many students simply added lead or silver rather than identifying the need to add lead or silver ions. No chemical equation was required.

19 cii) Not well done. The expected answer was a flame test. Conductivity was not accepted as it is not a conclusive test. Some students suggested tasting the solution, which is of significant concern.

QUESTION 20

Question	Answer	Mark Allocation	Comment
Q20	Graphite is a layer lattice where each carbon bonds to three other carbon atoms in a 2D layer. Between the layers is a sea of delocalised electrons. The delocalised electrons conduct electricity and the layers can slide over each other, hence graphite is soft. 	I I I	

COMMENTS FOR QUESTION 20

This question was reasonably well done, with most students able to explain graphite's conductivity. The requirement to draw a 3-D diagram proved challenging for some. The reason graphite is soft was explained poorly by some and others referred to "a delocalised electron for each layer".

Part E

Criterion 8

GENERAL COMMENTS

Students did not find this section challenging, but common errors were made throughout. Students need to read the questions carefully to make sure they use the correct information in their solutions. Overall, significant figures were adhered to and units were given.

In "show that" questions, detailed working **must** be shown. No marks were awarded for simply repeating the given value as the answer.

QUESTION 21

Question	Answer	Mark Allocation	Comment
Q21a	$M(NH_4Cl) = 14.01 + 4(1.008) + 35.45$ $= 53.49 \text{ g mol}^{-1}$	2	1 mark for 2 correct RAM values. 1 mark for fully correct calculation and M value Missing units: – 0.5
Q21b	$n(NH_4Cl) = \frac{m}{M} = \frac{22.1}{53.49}$ $= 0.413$ mol	1	The full calculation steps, required for full marks. 0.5 mark lost for missing units.
Q21c	$N = n \times N_A$	1	

Question	Answer	Mark Allocation	Comment
	∴ N(molecules) = $0.413 \times 6.02 \times 10^{23}$ $:= 2.487 \times 10^{23}$ ∴ N(atoms) = $2.487 \times 10^{23} \times 6$ $= 1.49 \times 10^{24}$ atoms	1	
Q21d	$c = \frac{n}{V}$ In mol L^{-1}: $c(NH_4Cl) = \frac{0.413}{0.050}$ $= 8.26$ mol L^{-1} In g L^{-1}: $c(NH_4Cl) = 8.26 \times 53.49$ $= 442$ g L^{-1} or $c(NH_4Cl) = \frac{22.1}{0.050} = 442$ g L^{-1}	1 1	Many students did not attempt to find the concentration in g L^{-1}

COMMENTS FOR QUESTION 21

21 b) Some students lost marks for not including all steps in their calculations.

21 c) Most students only found N(molecules) rather than N(atoms), perhaps not understanding the difference between atoms and molecules.

21 d) Many students did not attempt to find the concentration in g L^{-1}

QUESTION 22

Question	Answer	Mark Allocation	Comment
Q22a	48 – 25 = 23 g	1	Conservation of mass should be used rather than mole ratios.
Q22b	n(C) = ½ x 0.415 = 0.208 mol	1	
Q22c	$n(Al) = \frac{89}{26.98} = 3.30$ mol $n(Al_2O_3)$ = ½ x 3.30 = 1.65 mol $M(Al_2O_3)$ = (26.98 x 2) + (3 x 16.00) = 101.96 $m(Al_2O_3)$ = 1.65 x 101.96 = 168 g	1 1 1 1	Poorly communicated. Molar mass calculations should not include coefficients from the balanced reaction. Conservation of mass was an alternative method, but many errors were made using this method.

COMMENTS FOR QUESTION 22

22 b) Well answered, but some students multiplied by 2 rather than dividing.

22 c) Poorly communicated. Molar mass calculations should not include coefficients from the balanced reaction. Conservation of mass was an alternative method, but many errors were made using this method.

QUESTION 23

<table>
<tr><th>Question</th><th>Answer</th><th>Mark Allocation</th><th>Comment</th></tr>
<tr><td>Q23a</td><td>
<table>
<tr><td></td><td>H</td><td>C</td><td>O</td></tr>
<tr><td>n</td><td>$\frac{2.24}{1.008}$</td><td>$\frac{26.7}{12.01}$</td><td>$\frac{71.1}{16}$</td></tr>
<tr><td></td><td>2.22</td><td>2.22</td><td>4.44</td></tr>
<tr><td>Ratio</td><td>$\frac{2.22}{2.22}$</td><td>$\frac{2.22}{2.22}$</td><td>$\frac{4.44}{2.22}$</td></tr>
<tr><td></td><td>1</td><td>1</td><td>2</td></tr>
</table>
∴ molecular formula is HCO_2
</td><td>2

1

1</td><td>The final answer presented should match the working.</td></tr>
<tr><td>Q23b</td><td>Empirical mass = 1.008 + 12.01 + 2(16) = 45.02
Ratio = $\frac{90.03}{45.02}$ = 2,
2 x HCO_2 = $H_2C_2O_4$</td><td>1</td><td></td></tr>
<tr><td>Q23c i</td><td>Does not fully dissociate/ionise in solution</td><td>1</td><td></td></tr>
<tr><td>Q23c ii</td><td>5</td><td>1</td><td>A range 3 – 6 was accepted.</td></tr>
<tr><td colspan="4">COMMENTS FOR QUESTION 23</td></tr>
</table>

23 a) This simple empirical formula question was mostly well answered. Sometimes, poor communication meant there was little indication of understanding.

23 c) Students needed to specify a pH value rather than give an explanation.

QUESTION 24

Question	Answer	Mark Allocation	Comment
Q24a	$2HCl_{(aq)} + Na_2CO_{3(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$	1 1	Correct products, balancing and subscripts required
Q24b	$(Na_2CO_3) = \frac{m}{M}$ $= \frac{0.373}{105.99}$ $= 3.52 \times 10^{-3}$ mol $n(HCl) = 2 \times n(Na_2CO_3)$ $= 7.04 \times 10^{-3}$ mol $c(HCl) = \frac{n}{V}$ $= \frac{7.04 \times 10^{-3}}{0.0284} = 0.248$ mol L^{-1}	1 1 1	Mole ratio.
Q24c	$C_1V_1 = C_2V_2$		Alternative methods possible.

	$0.25 \times 1.0 = 0.20 \times V$ $V = \frac{0.25}{0.20} = 1.25$ L ∴ add 0.25 L to the 1.0 L solution to reduce its concentration to 0.20 mol L^{-1}.	1 1	

COMMENTS FOR QUESTION 24

24 a) Formula sheets should be used as a guide for products formed.

24 b) Students should read the question carefully to ensure they are using the correct value for the correct substance.

Many students lost a mark for missing the mole ratio.

24 c) Most students missed the last step of subtracting 1 L.

QUESTION 25

Question	Answer	Mark Allocation	Comment
Q25a	$HBr_{(aq)} + NaOH_{(aq)} \rightarrow NaBr_{(aq)} + H_2O_{(l)}$	1 1	Correct products Balance and subscripts.
Q25b	The acid donates a proton (H^+) to the base which accepts it.	1 1	Answers that explained pH changes and neutralisation were awarded no marks if they did not refer to Bronsted–Lowry acid.

	HBr was the proton donor and NaOH was the proton acceptor.,	I	
Q25c i	$2HBr_{(aq)} + Mg_{(s)} \rightarrow MgBr_{2(aq)} + H_{2(g)}$	I I	Correct products Balance and subscripts.
Q25c ii	Bubbles of gas Mg strip dissolved / disappears	I	No marks were given for answering 'pop-test' or 'a gas was formed'.

COMMENTS FOR QUESTION 25

25 a) Students should read questions carefully. Some attempted to include Mg in the equation. Many students wrote H_2O as HOH or OH_2. The solubility table should be used to check the state of the salt. In a chemical equation of this form, students should not include charges in the chemical formula

25 b) Students need to remember that the formula for magnesium metal is $Mg_{(s)}$, **not** Mg^{2+} and hydrogen gas is $H_{2(g)}$.

25 c) When observations are required students need to describe what can be seen and heard.