PHYSICAL SCIENCES (PSC315114)

This exam was successful in allowing students to show their depth of understanding of the topics examined. Each part contained a good spread of questions to cover the course work and to challenge even the most capable of student.

Markers were disappointed by the careless use of scientific terminology in both the Physics and Chemistry sections. Unfortunately, poor spelling is always evident – ‘flourine’ instead of fluorine, and ‘drown’ rather than drone.

When completing numerical problems students should carefully write out the equation and show the substitutions. Too often the equation was written out incorrectly (eg \( s = ut + \frac{1}{2}at^2 \) instead of \( s = ut + \frac{1}{2}at^2 \)). After correct substitutions, there were too many careless errors – eg forgetting to square a number and inappropriate transposing of numbers/pronumerals.

When information is given in **bold** it is a hint to use it when answering the relevant question.

The final section of this report contains sample answers to the exam. There are alternate ways to respond to some of the questions. These alternatives are usually referenced in the ‘comments’ section of this report; students should discuss alternative answers with their teacher. The marking panel would like to acknowledge the work of Jane Hall-Dadson for preparing these answers.

PART I – CRITERION 5

QUESTION 1

(a) Overall, Part (i) was well done but candidates should be careful to use the correct number of significant figures.
   A lot of students neglected to include direction in Part (ii).

(b) It was disappointing to see the poor quality of diagrams in Part (i). Many students neglected to draw their diagram with any semblance of proportionality; vectors were not always drawn as arrows placed top to tail. Identifying the appropriate angle needs improvement as it is often needed in subsequent calculations. After correctly using Pythagoras’s theorem to find the magnitude of displacement in Part (ii), many candidates did not calculate the direction. SE (ie an angle of 45°) was often incorrectly stated as the angle; it is 25.7°E.
   In Part (iii) markers accepted units of either km/h or m s\(^{-1}\) but the lack of the inclusion of the angle was too frequent in this vector problem.

QUESTION 2

(a) Poorly answered overall. Examiners were looking for the same magnitude of arrow for \( F_g \) in all diagrams, equal arrows showing \( F_g \) and \( F_r \) (diagram i) increasing air resistance (diagram ii and iii) and no upward force (diagram iv).

(b&c) Mostly well done, but candidates are encouraged to write out formula and show substitution.

(d) Students should correctly identify and state the direction (eg \( \downarrow \) is +) and keep this consistent throughout the substitution into the formula.
(e) When plotting graphs students should label axes clearly and plot points accurately. Use a ruler to draw straight lines.

QUESTION 3

(a) Well answered, although a disappointing number of candidates incorrectly used kg as the unit of weight rather than N.

(b) Most candidates calculated the magnitude of \( F_{\text{net}} \). Many forgot to include a direction (up or \( \uparrow \)). Relatively few students were able to determine the force generated by the propellers (\( F_{\text{th}} \)) by considering that \( F_{\text{net}} = F_g + F_{\text{th}} \).

(c) Well answered.

(d) Correct answers were rare, with many not attempting the question. Of those that did, part marks were obtained by calculating the velocity of the box as it was released (2.25 m s\(^{-1}\) up). Many students did not realise that the box continues to move upwards, once released, till the velocity becomes 0 due to the force of gravity slowing it. The fact that the box was subjected to two accelerations, (0.75 m s\(^{-2}\) up on ascent and 9.81 m s\(^{-2}\) down on descent) challenged most candidates.

(e) The well-prepared student could eloquently link falling on the mat to increased time/distance of stopping. Too many students just wrote out one of Newton’s laws and did not address the question. Students are expected to reference the law used (e.g., Newton’s 2\(^{nd}\) Law).

(f) Many students did not answer the question asked: Explain this slow acceleration. They just wrote: more mass, so increase force to get it accelerating. True, but not the answer to the question asked! A surprising number of students wrote out force equals mass times acceleration. Why not write \( F_{\text{net}} = ma \)? A lot quicker and is actually more accurate. Only a few candidates realised that \( F_{\text{net}} \) is reduced, assuming the drone’s propulsion remains constant. (Since the question was only worth 1 mark, the omission of this point was not penalised.)

(g) The best answers included a diagram to show \( F_g \) and air resistance were equal in magnitude and opposite in direction. Many students did not make it clear to the marker that the equal forces were in opposite directions or that the pizza box was actually moving when it experienced these forces. Acceleration due to gravity is not a force; it is acceleration.

QUESTION 4

(a) This straightforward horizontal projectile motion was well done by those who took the time to separate the horizontal and vertical parameters. Too often the vertical distance was incorrectly combined mathematically or vectorially with horizontal speed.

(b) Overall, well answered. Any errors relate to comments mentioned above.

(c) Stating Newton’s Third Law does not answer the question and Newton’s Third Law does not cause the cannon to move back. Newton’s Third Law can explain the situation. So forces ON the projectile and ON the cannon are relevant. A few students expertly used Conservation of Momentum principles.

QUESTION 5

Students used symbols indiscriminately (\( p, u, v \) and \( m \)) with no explanation that it was \( u \), the initial momentum of the system (usually written as \( p_i \)), or a final velocity of the ice skater. Students applied conservation of momentum with varying degrees of success. Quite a number forgot to include the initial momentum of parcel in their calculations. Since examiners were not looking for a final numerical answer, some interpretation of the calculated value(s) was expected — either that the \( v = 0.247 \) m s\(^{-1}\) meant the ice skater was still moving north, or, if initial momentum and final momentum were calculated, that the ice skater still had momentum, so was still moving.
PART 2 – CRITERION 6

QUESTION 6

This question allowed students to demonstrate a wide range of skills, from simple calculations to more involved problem solving. The mathematical aspects of the problem were generally well handled, but some common misconceptions were revealed.

(a) Generally well done. The most common error was forgetting to square the velocity term.

(b) Again, generally well done. A number of candidates could not rearrange to make \( h \) the subject of the equation.

(c) The vast majority of students demonstrated major misconceptions. The most common error present in the majority of responses suggested that a lower mass would result in a lower kinetic (true) energy and thus a lower height would be attained (false). A number of successful approaches were presented including algebraic or numerical demonstrations that the height is independent of the mass, or discussions of work and energy or acceleration.

(d) Poorly handled. Many students equated forces and energy (or work) revealing misconceptions about the relationship between these fundamental physical concepts.

(e) This question provided an opportunity for students to demonstrate their ability to solve a multi-step problem. Many responses employed a robust method, yet students frequently did not account for the initial kinetic energy or final gravitational potential energy. Students who had memorised \( v = \sqrt{2gh} \) as an approach to similar problems were not able to demonstrate adequate conceptual knowledge. A small minority of students used the equations of motion from Information Sheet, but often some conceptual errors. These students missed the opportunity to demonstrate an understanding of energy conservation.

QUESTION 7

The majority of candidates handled this question very poorly. Given the multitude of possible calculation errors and opportunities to carry these forward, it was imperative that students supported their responses with some working or commentary.

(a) The term ‘potential energy’ does not uniquely refer to ‘gravitational potential energy’. It is important that students are familiar with, and can make appropriate use of the terminology set out in the course document. Stronger responses featured this terminology along with terms such as light energy or electromagnetic radiation rather than the frequent references to solar energy or sun energy. Many students were unfamiliar with the operation of a solar panel.

(b) Well done by most.

(c) The vast majority of candidates simply multiplied 3 MJ by 35%, resulting in an answer (1 MJ) that violates the Law of Conservation of Energy. A number of candidates recognised this issue and attempted to address it by summing the two values (3+1 = 4 MJ). A smaller, but notable number of candidates tried a similar process using 65% (or 165%). By far the least common approach was the correct one.

(d) Some students had memorised that a factor of 3.6 was involved in this conversion, but few applied it correctly.

(e) Students who could not complete part d) but recognised that they could use their response from part c) are commended. This approach had fewer issues with inconsistent units. Candidates who used their answer from part d) in kWh frequently made errors with the units such as kWh / h = W or kWh/s = kW.
QUESTION 8

This question provided a familiar context for circuit analysis. Most students could correctly calculate the total resistances but not the currents. This is indicative of conceptual issues, as the resistance formulae require very little interpretation to be correctly applied. Students frequently wrote amps and ohms instead of using the appropriate unit symbols.

(a) An easy mark for most candidates.

(b) This was the most poorly understood section of the question. The common incorrect responses divided the voltage by 16 Ω or by 99 Ω.

(c) Generally well done, but frequent calculator errors.

(d) Students had better success with this question, compared with part (b). The most common incorrect response used the total resistance instead of 16 Ω.

QUESTION 9

This question proved to be a good assessment tool to differentiate between candidates of varying ability. Most candidates were able to correctly answer the formulaic parts of the question, however, only strong candidates were able to use the charge on an electron to correctly identify the number of electrons. Students are to be familiar with the graphical relationship between voltage and current where either variable is plotted on the independent axis.

(a) This question was very straightforward; nonetheless, a disappointing number of students simply wired both meters in parallel or series. Part marks were awarded in this case. Students are encouraged to use the symbols as represented in the course document.

(b) This question was generally well done. Some students had difficulty rearranging the equation, or did not use one second as the time. (Units of Coulombs or Coulombs per second were accepted.)

(c) This question proved very challenging to the vast majority of candidates. Many students incorrectly tried to multiply the charge from part (a) by the charge on the electron. Future candidates are also strongly encouraged to practice using their calculators to work with scientific notation as a plethora of incorrect answers were presented based on the correct working out.

(d) Most candidates were able to successfully answer this question, although some used longer strategies calculating resistance or energy change first, rather than using P=VI which was much simpler.

(e) The ohmic (linear) nature of the resistor was graphed well, with most candidates who attempted this question correctly plotting the relationship based on the data given.

(f) This question proved extremely challenging. The most common answer involved the resistance decreasing with increased voltage, which indicated that students had remembered the shape of the graph when current is presented on the x-axis. Part marks were awarded for this response.

QUESTION 10

This question assessed a wide range of knowledge regarding radioactive decay and consequently a wide range of results was achieved.

(a) This question was straightforward, however, it required 4 pieces of information for one mark. Students are encouraged to ensure they are familiar with the isotopic notation, $^{4}E$, as this is frequently used in responses and leads to errors in calculations when used incorrectly.
(b) This question was quite well done with the exception of the students who did not understand the isotopic notation, so could not balance decay equations with the correct notation for alpha particles. A large number of students also tried to bombard radon-222 with a helium nucleus.

(c) This question was well answered. Part marks were awarded when students showed logical working out but did not read the scale of the graph correctly or answered with days or years rather than hours.

(d) A number of students simply stated background radiation with no explanation rather than recognizing the random nature of decay or stating that background variation would affect low counts after 300 hours.

(e) Part marks were awarded for most answers indicating that background radiation was from a variety of sources throughout Earth and the universe, however, to achieve full marks students needed to indicate that background radiation was ionising. Students should also note that background radiation could be harmful; it is just unlikely.

(f) This question assessed students’ understanding of the difference between ionising and non-ionising radiation and candidates overwhelmingly gave poor responses.

(g) This question provided a stimulus regarding the collection of radon gas in buildings in the USA. As such, the markers were looking for candidates to explain that lung cancer could be attributed to breathing in radon-222, which then undergoes alpha decay inside the lungs, rather than breathing in alpha particles. Most students commented on the ionisation caused by alpha particles and the effect on tissue so gained reasonable marks.

**QUESTION 11**

This question was generally answered well by the majority of candidates.

(a) Candidates frequently omitted the mass of the bombarding neutron in their calculations to determine the mass of the other daughter isotope. It was also common for students to represent the three neutrons produced as a single neutron with a mass of 3.

(b) This question posed a problem for those candidates unfamiliar with fission chain reactions, who instead explained the process of decay sequences.

(c) A large number of students were able to discuss the implications of fission chain reactions, some giving details like control rods used in power plants, but the weaker students simply said uncontrolled chain reactions were bad.

**PART 3 – CRITERION 7**

There was a widely observed misuse/confusion of basic chemical terms such as molecule, atom, element, compound and substance throughout this section. Candidates misused the term “intermolecular forces” throughout, especially when referring to ionic bonding.

**QUESTION 12**

This question was mostly well done.

When naming, the most common error was the omission of roman numerals in the naming of copper(II) chloride. Many students incorrectly gave ‘sulfite’ as the systematic name of SO₂, despite it not being an ion. A high number of students could not recognise that the chemical symbol ‘S’ represents sulfur; incorrect alternatives were silicon and sodium. In column 2 what should have been an easy introduction to Part 3, the symbol for tin (Sn) gave rise to a variety of incorrect responses – including Tn, Fe, Al and even AlPO₄. Neglecting to write the symbols for the
ions in calcium permanganate solution was a common error in column 3. Candidates gave their answer as (−) and (+), without the chemical formula to accompany those signs (MnO₆ and Ca²⁺).

**QUESTION 13**

(a) Students should use dots/crosses to represent all valence electrons when drawing electron dot diagrams, rather than a line to represent a bonding pair. Bohr/Rutherford diagrams were not accepted.

(b) Full marks required mention of the types of bonding in each compound, the reason for their relative bonding strength, and a statement regarding the amount of energy required to break the relevant bond. As such, most candidates struggled to obtain full marks. Often candidates attempted to justify the different states simply by stating that H₂S was covalently bonded and Na₂S was ionic, without further explanation. Some candidates based their explanations on the physical properties of the constituent elements (mostly in regard to H being a gas, and Na being a solid) and extrapolated them to justify the state of the compounds. Other candidates stated that both compounds were covalently bonded, and mistakenly referred to covalent network bonding for both compounds.

**QUESTION 14**

Most candidates scored well on this question, with many gaining all 6 marks.

(a) In Part (i) markers were disappointed to see the large number of common mathematical errors eg the translation of percentage abundance into the appropriate decimal (e.g. 90.2 % often became 0.92, or 9.80% became 0.98) and calculating the average of the two mass numbers, without considering the relative abundances at all. As this is a relative atomic mass calculation, units are unnecessary. Marks were not deducted for candidates who used g mol⁻¹ or amu, but candidates who expressed their answers in grams were penalised ½ mark.

In Part (ii), a number of answers were accepted, including: existence of other isotopes, that mass number does not represent the actual mass of the isotopes; and the number of significant figures used in the data.

(b) In Part (i) too many candidates stated that the chemical reactivity of neon was “low”, a response which gained no more than ½ mark.

In Part (ii) candidates were generally able to recognise that neon was unreactive due to its full outer shell of electrons, however, there were candidates who simply answered that it is a noble gas, with no reference to electron configuration.

(c) The majority of candidates did well on this question. Quite a number made reference to nuclear composition, seemingly confusing the term ‘reactivity’ with ‘radioactivity’. Other candidates attempted to answer with a simple ‘yes’ or ‘no’, as opposed to the required ‘same’ or ‘different’ specified in the question. These responses were given credit if they provided a subsequent explanation that clarified their answer.

**QUESTION 15**

(a) Quite well answered. A common error was using the definition of an isomer. There was also confusion as to whether allotropes involved elements or compounds. Some candidates thought allotropes referred only to different forms of carbon.

(b) Most of the available marks were given for the explanation, rather than the prediction. Many candidates seemed to confuse graphene with graphite, often writing ‘graphite’ in their responses. Often, candidates realised that delocalised electrons were the cause of the conductivity but could not explain where the electrons came from.
(c) Again, most marks were allocated based on the explanation. Candidates often realised that this was a strongly bound covalent network structure, but then failed to draw the connection between high melting point and energy required to break the covalent bonds. A number of candidates referred to metallic bonding throughout question 15, believing that only metallic compounds conducted electricity and had high melting points.

**QUESTION 16**

(a) Most students recognised that period 2 elements have their electrons located in the first two electron shells. Though many students received half marks for ‘have the same number of shells’ without stating how many. The most common mistake was discussing the electron configuration of group 2 elements.

(b) Many students responded with either combination group II & V or group (2 & 15). Half marks were awarded for the combination group 2 & 5.

(c) This question was not well answered. Better answers identified lithium’s lower nuclear charge (or fewer protons in the nucleus) as responsible for the lesser attraction of the valence electrons, hence the largest atomic radius.

(d) Very poorly answered. Most students interpreted the question as more bonds rather than type of bond. Students then focused on fluorine having more valence electrons than lithium therefore more possibility of forming more bonds rather than focusing on types and explaining how these types came about. General statements such as fluorine is a non metal, therefore it forms multiple (single, double and triple!) covalent bonds with all other non-metals or lithium only has one valence electron and so it can only form one bond were made without reference to what types of bonds. Less than half the students explained why/how ionic and covalent bonds form. Many stated that ionic bonds were ‘sharing’ electrons.

(e) Mostly well answered. However, many students received half marks for ‘have the same number of valence electrons’ without stating how many.

(f) Markers were quite generous as many students listed reasons with no contrast eg hydrogen is a gas and does not exhibit metallic bonding rather than saying hydrogen is a non-conducting gas while all other group 1 elements are conducting solids. Hydrogen exists naturally as a covalently bonded molecule, whereas group 1 elements atoms bond metallically.

Many students are unaware hydrogen could accept an electron. Many responses could have excluded hydrogen from any number of groups not just group 1 which was the main focus of the answers required.

More students were under the impression that as hydrogen only had one electron it could not lose it, otherwise it would cease to exist! They did not make the connection with H⁺ ions!

**QUESTION 17**

(a) Generally well done. Common errors included forgetting to add all hydrogen atoms, omitting di- for 1,2 dimethyl or cyclo (if used) or identifying the –yne using the smallest numbering system. A ½ mark was deducted for each error.

(b) Well answered. Most students correctly stated the molecular formula for Y & Z to support their answer. Some students just listed the general formula for alkynes and cyclic alkene from the data sheet without identifying that to be isomers they had to be the same molecular formula.

(c) Most students recognised this as an addition reaction. However, there were a number of incorrect resulting structures including HCl adding to both sides of the double bond OR the double bond was left alone and an H and a Cl atom were added to the two adjacent carbon atoms.
(d) Many students recognised X was an alkane and therefore would have the slowest substitution reaction with bromine. However, many students were unable to explain why. Better responses recognised more energy was required to break the single bonds in a saturated hydrocarbon (alkane) and that UV light was required and hence reaction was slower compared with unsaturated compounds.

QUESTION 18

There were a significant percentage of students who left this question blank.

(a) Many students did not answer this straightforward question correctly. Most recognised C₃, then did not use the empirical formula data appropriately.

(b) Very mixed responses to this question. While many students who attempted the question were able to write a full balanced chemical equation for complete combustion including relevant subscripts, a fair proportion of students did not seem to know the products of a combustion reaction, therefore could not balance the reaction effectively. Of interest was that a number of students indicated hydrogen rather than water was the second product of combustion. A number of students also included (aq) or (s) in the subscript for the hydrocarbon, though many ignored subscripts altogether.

PART 4 – CRITERION 8

QUESTION 19

(a) Many students did not answer Part (i) and so missed gaining an easier mark. In Part (ii) many students could not distinguish between products and reactants or convincingly name covalent compounds.

(b) Generally well done, with ½ mark deducted for each mistake or omission.

(c) Many students did not write a net ionic equation in Part (i). In Part (ii) the charge on the ion was omitted too often.

QUESTION 20

(a&c) Generally well done.

(b) Many students calculated the ratio but could not give the correct empirical formula.

(d) This part was well done by those students who had the appropriate data from parts (b) and (c).

QUESTION 21

(a) Generally well done. Students needed to show evidence of calculating the molar mass to demonstrate they were not just using the value given for n(NaHCO₃).

(b) Many students failed to consider the mole ratio in this calculation.

(c) Generally well done. Providing the expected observation makes the answer more complete.

(d) Many suggestions were offered; however, the gaseous nature of the products was the clue.
QUESTION 22

(a) Reasonably well done, where attempted. The main difficulty was the initial conversion of the mass of H₂S into grams but, once done, finding the moles and number of molecules was done well. Many students only found the number of moles and stated this was the number of molecules!

(b) The weak acid definition was not well known, with some trying to relate it to pH instead of degree of dissociation. The equation was also not well done, with ionic charges and states frequently omitted and H⁺(aq) not included.

(c) Some confused the definition concentration ie moles per litre and tried to evaporate water to concentrate the solution. Students needed to recognise the significance of the partial solubility of H₂S.

QUESTION 23

A variety of responses were presented, ranging from the expected acid to less obvious chemicals. Some used inappropriate chemicals such as solid reagents or simply stated an ion that could be added eg hydroxide.

Markers were looking for two distinct observations – one for NaCl and one for Na₂CO₃. Expected observations included solids dissolving and bubbles of gas appearing for example, rather than simply that a salt and gas were produced. Too many candidates incorrectly concluded that an acid and carbonate would produce H₂CO₃, despite the general equation being on the information sheet.

The chemical equations were reasonably well done if parts (a) and (b) were completed well; again, missing/incorrect states and incorrect balancing were evident.

QUESTION 24

(a) There were several references to a colour change to pink despite the presence of an indicator not being mentioned. Some neglected to state that the pH would decrease, rather just saying that it went towards 7.

(b) Reasonably well done although omitting the mole ratio was common, as was not converting to litres.

QUESTION 25

(a) Well answered.

(b) Not well done. Part marks were awarded if evidence of a mole ratio (1:2) was present. Students thought this question was harder than it actually was. Many candidates did not see that the concentration of CaCl₂ was given in the question.

(c) Many varied and accurate methods were offered, which was pleasing. However, many were unable to answer the question accurately, incorrectly identifying that their calculations indicated that the solution was saturated when it was clearly below the amount provided in the question.

(d) Most could offer the correct prediction, however, then incorrectly assumed that the hydrated salt meant that there were more water molecules to dilute the solution.
Physical Sciences - TASC Exam
November 2017 - Answers

Part 1 - Criteria

(a) \( \frac{\text{distance}}{\text{time}} = \frac{12,300}{10} = 1,230 \text{ m} \times 0.607 \text{ km}^{-1} \)

\[ 0.607 \times 3.6 = 2.19 \text{ km}^{-1} \]

\( \textbf{b) (i)} \)

\[ v = \frac{S}{t} = \frac{25 \text{ m}}{5} = 5 \text{ m/s} \]

\[ = 18.0^\circ \text{ North} \]

\( \textbf{b) (ii)} \)

\[ S^2 = 2.5^2 + 11^2 \]

\[ = \sqrt{15.5625} \]

\[ S = 3.94 \text{ km} \]

\[ \tan \theta = 1.75 \text{ at} 35^\circ \]

\[ \theta = \tan^{-1} 0.4817 \]

\[ \theta = 25.1^\circ \]

\( \textbf{b) (iii)} \)

\[ v_{ax} = \frac{S}{t} = \frac{25 \text{ m}}{5} = 5 \text{ m/s} \]

\[ = 1.71 \text{ km} \text{ swimmer's displacement} \]

\[ = 3.94 \text{ km} \text{ S25.1}^\circ \text{E} \]

\( \textbf{b) (iv)} \)

\[ s = \frac{v^2}{2a} \]

\[ = \frac{2.5^2}{2 \times 2.9} \]

\[ = 2.94 \text{ km/h} \text{ S25.1}^\circ \text{E} \]

\[ = (3.94 \times 3.6 = 1.09 \text{ ms}^{-1} \text{ S25.1}^\circ \text{E}) \]

Q2.

a) \( F_w = mg = 600 \times 9.81 \)

\[ = 4,911 \text{ N down} \]

b) \( F_{net} = ma = F_{lift} + mg \text{(up)} \)

\[ = 5,000 \times 0.750 = F_{lift} + 5,000 \times 9.81 \]

\[ F_{lift} = 3.75 + 49.01 \]

\[ = 52.8 \text{ N up} \]

c) \( u = 0, a = 0.75, t = 3 \)

\[ s = ut + \frac{1}{2}at^2 \]

\[ = 0 + \frac{1}{2} \times 9.81 \times 3.00^2 \]

\[ = 3.38 \text{ m} = 3.4 \text{ m up} \]

d) \( \text{drone rising, } \theta = \text{ pizza} \)

\[ 0 \]

\[ \theta = 22.5^\circ \cos 0 = -98 \]

\[ v^2 = u^2 + 2as \]

\[ = 2.25^2 + 2 \times 9.81 \frac{0.258}{5.06} \]

\[ = 5.06 - 19.62 \frac{0.258}{5.06} \]

\[ = 3.82 \text{ m} + 0.258 \]

\[ = 3.64 \text{ m} \]

\( e) 

\[ F_{net} = ma, a = \frac{dv}{dt}, \text{ The mass will increase the time it takes for the pizzas to topple, thus decreasing the force of the} \]

\[ 1 \]
Q.3a (continued)

With pizzas weight = mg is greater and as Fnet (up) = Fnet (up) + Fnet (down). Fnet is smaller and acceleration is less.

9.) As velocity increases so does our resistance force Fv and Ff when weight force and Ff are equal Fnet = 0 and no further acceleration is possible velocity reaches maximum terminal velocity.

Q.4a. Here is u = 4.90m/s a = 0.5 = 0.455m/s

Vertical: u = 0, a = 9.8, s = 0.455m

(a) t = ? (from vertical)

\[ s = ut + \frac{1}{2}at^2 \]

\[ 0.455 = 0 + \frac{1}{2} \times 9.8 \times t^2 \]

\[ t = \sqrt{\frac{0.455}{4.90}} = 0.305 \text{ s} \]

s = ut + \frac{1}{2}at^2 = 4.90 \times 0.305 + 0 = 1.49 \text{ m}.

1.49 + 1.65 m, so block lands in front.

(b) S\textsubscript{H} = 1.65, u\textsubscript{f} = 4.90 m/s, t = ?

\[ S\textsubscript{H} = ut + \frac{1}{2}at^2 \]

\[ 1.65 = 4.90 t + \frac{1}{2} \times 9.8 \times t^2 \]

\[ t = 0.305 \text{ s} \]

S\textsubscript{V} = 0 + \frac{1}{2}at^2 = \frac{1}{2} \times 9.8 \times 0.305^2 \]

\[ = 0.557 \text{ m} \]

(c) N13 - for every action there is an equal & opposite reaction.

The cannon exerts force on projectile (forward) projectile exerts force back, so cannon moves back.

Q.5. \( P_{\text{initial}} = m \cdot v (\text{North} +) \)

\[ P_c = (52.8 + 2.10) \times 0.435 \]

\[ = 23.9 \text{ kgs} \cdot \text{m/s} \text{ North} \]

Let \( P_c = P_{\text{final}} \)

\[ v = 23.9 = 52.8 \text{ m/s} + 2.10 \times 5.16 \]

\[ v = 23.9 - 10.8 = 0.248 \text{ m/s} \]

\[ v = 52.8 \text{ m/s} \]

The skater is still moving north.

Part 2: Criterion 6

Q.6. a) \( E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 1.35 \times 1.96^2 \]

\[ = 2.59 \text{ J} \]

b) \( E_k \rightarrow E_p = mg \cdot h \)

\[ h = \frac{23.9}{30.9 \cdot 0.81} = 0.196 \text{ m} \]

(c) As \( E_k \rightarrow E_p \) \( \frac{1}{2}mv^2 = mg \cdot h \)

and masses cancel out.

Yes, each trolley will reach same height.

d) \( E_{\text{lost}} = \text{Work done by friction} \)

\[ E = F \cdot s = 0.065 \times 10.0 = 0.65 \text{ J} \]

Actual \( E_k = 2.59 - 0.650 = 1.94 \text{ J} \)

e) New \( E_k = E_{\text{initial}} + \Delta E_p \)

\[ = 2.59 + mg \cdot h \]

\[ = 2.59 + 0.35 \times 0.81 \times (1.37 - 0.39) \]

\[ = 2.59 + 1.165 = 14.2 \text{ J} \]

\( E_k = \frac{1}{2}mv^2 \)

\[ v = \sqrt{\frac{14.2}{0.365}} = 4.58 \text{ m/s} \]

Q.7a) Nuclear (nuclear) \rightarrow Light \rightarrow Electrical \rightarrow Kinetic \rightarrow Gravitational PE

cannon needs to be 0.557 m high.

b) \( E_p = mg \cdot h = 5.40 \times 10^3 \times 9.81 \times 5 \]

\[ = 31.07 \times 10^5 \text{ J} = 31 \text{ MJ} \]

c) \( 8.77 \times 10^5 \times 100 \times 35 = 8.77 \times 10^8 \text{ J} \)

d) \( 1 \text{ kWh} = 1000 \times 3600 \)

\[ = 3.6 \times 10^6 \text{ J} \]

e) \( 8.77 \times 10^5 \times 36 \times 10^6 = 2.44 \text{ kWh} \)

c) \( 2.44 \times \frac{1}{4} \text{ h} = 0.61 \text{ kWh} = 610 \text{ J} \)
(Part 2 continued)

Q8. a) \( R_T = R_1 + R_2 + R_3 = 15 \Omega \)  
   b) \( V = IR = 10 \times \frac{8.5}{10} = 0.85 A \)
   c) \( R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{8 \times 22}{16 + 22} = 10.7 \Omega \)
   d) \( I = \frac{V}{R} = \frac{8.5}{16} = 0.53 A \)

Q9. a) \( V = 12 V \)
   b) \( I = \frac{V}{at} \)  
   c) \( V = I = 12 \times 0.300 = 3.6 W \)

Q10. a) \( ^{12} \text{C} \) has 6 protons, 6 electrons 
   b) \( ^{212} \text{Rn} \rightarrow ^{4} \text{He} + ^{208} \text{Po} \)  
   c) \( 5350 \text{ s} = 2475 \text{ s} + 9.5 \text{ hours} \)  
   d) Decays is random, at low counts variation is more obvious. 
   e) Background radiation is ionising, waves or particles from terrestrial or extraterrestrial sources.

A microwave (phone) and visible light are non-ionising, having much less energy than background radio.

9) Radon gas can be breathed in. If it decays in the lungs, highly ionising alpha particles can damage the blood, leading to mutations and cancer.

Q11. a) \( ^{235} \text{U} + 12 \text{n} \rightarrow ^{139} \text{Ba} + ^{94} \text{Kr} + 3 \text{n} \)  
   b) \( ^{235} \text{U} \) produces 3 neutrons and can induce 3 more fission of \( ^{235} \text{U} \) atoms. 

The exponential increase is a chain reaction. 

Uncontrolled fission releases huge amounts of energy in a short time and explosion, bomb.

Controlled is used for nuclear power.

Part 2 - Criterion I

Q12

<table>
<thead>
<tr>
<th>Tin</th>
<th>Sn</th>
<th>covalent electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>sulphur</td>
<td>( \text{SO}_3 )</td>
<td>covalent molecules</td>
</tr>
<tr>
<td>copper</td>
<td>( \text{CuCl}_2 )</td>
<td>solid</td>
</tr>
<tr>
<td>calcium permanganate</td>
<td>( \text{Ca}(_{5}\text{MnO}_4))</td>
<td>solid</td>
</tr>
</tbody>
</table>

Q13

a) \( ^{35} \text{Cl} = \text{H}_2 \text{S} \)

b) \( ^{2} \text{H}_2 \text{S} \) has 2 non-metal atoms, bonded covalently to form molecules with very weak intermolecular attraction. It takes little energy to break these bonds and evaporate.

\( ^{2} \text{H}_2 \text{S} \) has a metal & non-metal with ionic bonding. The electrostatic forces holding its lattice together require a lot of energy to break so the melting point is high. Its solids at room temp.

Q14 a) \( ^{88} \text{Ar} = 80 \times \frac{0.26}{2} + 22 \times 1.00 = 20.1 \text{ AMU} \)

b) not a typical sample, or insufficient significant figures given in data.
Q14. Continued
b) Neon will be unreactive
ii) It has a full outer (valence) shell
   reactivity will be identical as:
   the electron structure of the
   isotopes is the same.

Q15
a) Allotropes are formed when the
   same element bonds in different
   ways to form structures with
   different physical properties.

b) Graphene will conduct as
   only 3 electrons are shared
   in the 2D lattice. Once
   each C is delocalised
   and can carry a current.

Q16. a) 2 electron shells
b) X = Gp 2 or II
   Y = Gp 15 or V

c) Lithium as it has the
   lowest nuclear change in the
   group so weakest attraction
   for electrons.

d) Fluorine is a non-metal that
   can either bond ionically by
   accepting electrons from a metal,
   or covalently by forming bonds
   with another non-metal. Lithium is
   a metal and can only form
   compounds with a non-metal
   by donating electrons to form ionic
   bonds.

e) All have one electron in outer orbit

f) Hydrogen is a gas, rather than
   a solid like metals. As a non-metal
   it can donate or share electrons
   bonding ionically or covalently.

Q17.
   a) X H-C-C-C-H
   H CH₃ H
   b) Y 4-methyl pent-2- yne
   c) Z 2,4-dimethylcyclobut-1-ene
   d) H CH₃
   e) H CH₃

Q18. a) C₃ H₆

b) 2C₃ H₆(g) + 9O₂(g) → 6CO₂(g) + 6H₂O
Part 4 - Criterion S

Q.20

a) A mass = 1.29 - 1.00 = 0.29 g

b) P

Mass = 1.00 g

No. mol = 0.0323

Ratio = 0.5

Formula: P₂O₅

c) m = 58.078 g/mol = 0.20 mol

M = n/M = 0.20 / 283.9 g/mol = 0.0007 mol

d) 1/5000 = 0.08494 mol

Ratio: Na₂CO₃ = 2

Molar Mass: Na₂CO₃ = 142.04 g/mol

Q.21

a) m = 58.078 g/mol = 0.0007 mol

M = n/M = 0.0007 / 142.04 = 0.0005 mol

b) M = n/M = 0.0007 / 142.04 = 0.0005 mol

C = n/V = 0.0007 / 0.0005 L = 0.0005 mol/L

Q.22

a) Concentrated acids have a large number of H⁺ ions in solution. As H₂S is only slightly soluble, saturation will occur before the solution is concentrated, so NO._

Q.23

- Use an acid eq HCl.
- NaCl will not react Na₂CO₃ will produce bubbles of CO₃(g)

Na₂CO₃ + 2HCl → NaCl + H₂O + CO₂(g)

Q.24

a) The pH will initially be high. It will decrease to pH 7 at equivalence.

b) HCl: CaCO₃ → CaCl₂ + CO₂(g)

Cₐ₃ = 2.84 × 10⁻⁷ mol

Ratio: HCl:CaCO₃ = 2:1

M = n M = 1.425 × 11.0 = 158.5 g CaCl₂

Q.25

c = 8.70 mol/L

V = 0.250 L

a) n = c V = 5.70 L * 0.25 L = 1.425 mol

m = n M = 1.425 × 110 = 158.5 g CaCl₂

b) CaCl₂ = 2 × CaCl₂

c = 74.5 g/L (saturated)

Q.26

a) 158.5 g/L * 50 mL = 158 g/L

M = 158 g/L / 158.5 g/L = 4.40 × 10⁻⁷ mol

N = n × Nₐ = 4.40 × 10⁻⁷ × 6.02 × 10²³

= 2.65 × 10⁷ molecules

-5-