PHYSICAL SCIENCES (PSC315118)

Whilst this examination was quite challenging, the range of questions gave prepared students ample opportunity to display their expertise. Students performed best in criterion 4, with a median score of 19/32. Students need to spend a maximum of 36 minutes answering questions in each booklet, as suggested on each cover, to ensure their performance on each criterion is reflective of the candidate's ability.

Using the reading time to read all questions, then re-reading carefully before they commence answering a question is good practice for candidates. Managing time to allow for checking of answers is ideal; the length of this examination may have precluded this.

The majority of students were able to solve simple, familiar calculations, with most giving answers to an appropriate number of significant figures. There were very few issues with units. A missed unit meant a candidate lost a maximum of 1 mark per criterion (½ mark in each half booklet). The same rule applied for a very inappropriate number of significant figures given in the final answer. A surprising number of students were unable to round off their answers correctly. As always, an extra step in a calculation is well worth the effort, as is a quick reflection on whether the answer is reasonable for the situation. Students need to always show their working; this is particularly important in 'show that' questions. If a marker can follow the candidate's line of thought through clear, but wrong, reasoning, part marks are invariably given.

Showing understanding of Physics and Chemistry concepts proved more problematic than completing calculations. The meaning of the term 'non-ohmic' was particularly poor. As always, questions pertaining to Newton's Laws challenged even the most capable student.

Too often students became muddled when they tried to use terminology beyond the scope of the course. Electromagnetism was used instead of electrostatic attraction; electronegativity was referred to as a force. It is also evident there are a number of misconceptions held by students. The non-existent 'covalent molecular bond' appears as an answer too often. The bond is covalent, the structure covalent molecular.

Candidates are reminded that they are allowed to bring a dictionary to the Physical Sciences exam.

Answers to the exam questions are included at the end of this report. They should be read in conjunction with the markers' comments. The marking team would like to acknowledge Jane Hall-Dadson's excellent work in completing the answers.

PART 1 – CRITERION 4

QUESTION 1

This proved to be a good first question, with about 60% of students gaining at least 5/7.

In part (a) the most common error was inversion of the atomic and mass numbers in the symbol.

In part (b), candidates did not always read the question carefully and follow direction; the answer required defining each term **and** stating the actual number. Too many gave part answers – EITHER quoting the atomic and mass numbers **or** giving the definitions. The definition of RAM was sometimes given instead of mass number.

Generally, part (d) was answered poorly. For 2 marks, candidates were required to identify that there was 1 more proton in Mg compared with Na, that both atoms had the same number of valence shells and that the extra proton created a stronger electrostatic attraction within the atom, hence smaller radius.

QUESTION 2

Part (a) was poorly answered. Common errors included:

- confusing isotopes with ions or isomers,
- incorrectly choosing X and Z as the isotopes, explaining this was because they had a different number of protons,
- explicitly referring to sulfur, and although this was not required, credit was given
- referring to the number of protons without specific mention of neutron numbers, and vice versa.

Part (b) was much better, but groups and periods were often confused. The group number was often incorrectly given as 5 rather than V or 15.

Part (c) was also poorly answered; a common answer was 6 valence electrons, which did not answer the question. A charge of 2, rather than –2, was too common.

Part (d) acted as a good discriminator. Clearly, many candidates do not understand the difference between ions and atoms and the inclusion of the word 'stable' confused many candidates, with mention of nuclear stability too common.

QUESTION 3

Most students gained at least ½ /1 in part (a). A beta particle was incorrect for the second observation, due to their higher penetrating ability.

Part (b) was poorly answered. Examiners were looking for a comparison of stability or half-life.

This concept examined in part (c) appeared for the second consecutive year, but was still quite poorly answered. Comparing the ionising nature of mobile phone emissions or reference to the em spectrum were equally acceptable answers.

Although between 2 and 3 marks were commonly given in part (d), this question demonstrated the inability of many candidates to plan their answer to address the specific guidelines given in the question. Mention of the relative penetrating and ionising abilities of alpha/beta/gamma emissions, both internal and external to the body was expected.

QUESTION 4

Half the students gained 2/4 for this question.

Part (a) and (b) were both well answered, although some students put the neutron on the wrong side of the equation in part (a) (½/1 awarded). Gamma and antineutrino were both acceptable responses, when paired with beta in part (b).

Part (c) was very poorly answered. Only a few students correctly stated that neptunium dioxide would have the same half-life as neptunium, and went on to explain that bonding chemically did not interfere with the decay of the nucleus.

QUESTION 5

Again, this question was well answered, with over 50% of students gaining at least 4 / 6.

Part (a) was well answered, with most students able to determine the number of half-lives that had elapsed, and then use this data to calculate the required fraction, presented as 1/16 or 6.25%.

In the next part most students recognised measuring background radiation as the reason in part (i). Part (ii) was more challenging, with few candidates achieved the maximum 2 marks. Many candidates neglected to subtract the original background count from the initial reading, and also forgot to add it back on at the end.

In the last part reference to a change in background radiation, or the random/spontaneous nature of nuclear decay were equally valid responses.

PART 2 – CRITERION 5

QUESTION 6

Nearly half the students gained full marks for this first question in Criterion 5.

In part (a) a couple of different approaches were possible, each requiring some conversion of units.

In part (b) the majority of students were aware of the difference between speed and velocity, and were able to identify that velocity requires a direction. Quite a few did not recognise that the SI unit for velocity is $m\ s^{-1}$, despite it being on the Information Sheet.

QUESTION 7

Despite the requirement to draw a vector diagram, the majority of students struggled to gain ½/1 in part (a). There are set rules for drawing vector diagrams. There are no short cuts.
Although the question in part (b) specified that the velocity should be calculated from the diagram, a number of students attempted to calculate it, invariably incorrectly, using an equation of motion.

It was pleasing to see that most students recognised that they needed to calculate an angle, but it is important to record this angle appropriately.

Part (c) was generally well done, although a significant number of students used values of acceleration other than 9.81 m s^{-2}. Despite there being a diagram of the path of the ball (i.e. projectile motion), quite a few students assumed that the ball was dropped from, then caught at, the same height leading to a displacement of zero.

Overall, part (d) was poorly answered. There is no air resistance, so the v ~ t graph should have a constant gradient of about 10 m s^{-2} and the s ~ t graph should have an increasing gradient. This was an easy three marks for students who were able to do a simple sketch of each. Most students were not able to get half marks in this question. Good sketch graphs included information contained in the stem of the question or calculated in part (c).

QUESTION 8

Students found both question 8 and 9 difficult. 'Forces' questions invariably present challenges for students. Newton's Laws involve complex concepts that require a deeper understanding than first appear.

The majority of students were able to identify the significance of the point in part (a).

Part (b) was less well answered, with many students referring to the gradient as a measure of velocity rather than acceleration.

In a question where a graph is provided, students should use it to calculate the displacement. Since the **approximate** displacement was required in part (c), it was valid to note that the area under first two triangles cancelled each other, and hence only determine and interpret the area under the third triangle. The students who calculated the displacement using an equation of motion generally used t = 1.2 s, so their answer was incorrect.

Part (d) was answered very poorly. Most students were unable to identify and suitably label the weight force so lost easy marks. Students needed to recognise that the third diagram requires a net upwards force as the ball is accelerating up. Lots of students incorrectly included upwards forces, including thrust, in more than one diagram; many used 'g' to label the weight vector, rather than f_g or similar; and arrows were not drawn from the centres of mass. Students are encouraged to use rulers and to attempt to draw to a reasonable scale. It is also important to remember that the object will not change its motion if $F_{net} = 0$.

QUESTION 9

When answering part (a) quite a few students did not consider the different lengths of arrows representing the forces on the spacecraft, or interpreted the question as a choice between action and reaction. Students often did not read the question and missed hints like 'back to earth' or 'in the atmosphere'. Generally the term 'drag' was misunderstood.

Many students did not address the question in part (b), and just stated one of Newton's Laws. Too many students said there were unbalanced forces acting, despite describing forces in part (a) as balanced. The term action/reaction pair is not well understood.

When answering part (c) many thought the astronaut would fly to the top of the craft and often assumed there was no gravity acting on the descending the spacecraft.

When calculating weight in part (e), units were often given as kg, rather than Newtons, so students did not distinguish between weight and mass. This led to other problems in subsequent sections of this question.

A number of students subtracted, rather than added, the two forces together when answering part (e). Sketching the vectors helps to answer this type of question.

Numbers appeared out of nowhere when students attempted to answer part (f). Quite a few used their answer for part (e) rather than the net force. Rarely did students give a comparison of the numerical calculation and expected value.

QUESTION 10

The final question in Criterion 5 was well answered, with over a quarter of students gaining at least 3.5/4.

Exponents were not well handled, and too many forgot to square *v* in part (a). In part (c) the direction was often not stated. Students found the word 'impulse' confusing.

PART 3 – CRITERION 6

QUESTION 11

A range of concepts was examined in this question. Overall, students found it difficult.

In part (a) the energy changes/transformations were very poorly covered. The most common error was to state kinetic energy was converted to potential energy. Parts (b), (c) and (d) were well done. Part (e) was poorly done with many students trying to use Newton's laws rather than the easier conservation of energy approach. (It is in the energy part of the exam) Part (f) required an understanding of kWh, which many candidates clearly did not have. Percentage calculations were an issue again this year.

QUESTION 12

Well done, however, the usual issues of no direction and incorrect units was evident in answers.

QUESTION 13

Approximately 25% of students gained full marks. A common error was trying to use V = IR rather than a power formula in part (a). Once part (a) was not answered, students were unable to answer part (c). Too often markers were told a non-ohmic conductor is one that does not obey Ohm's Law. This is incorrect - **all conductors obey Ohm's Law** at a given voltage or current. Non-ohmic conductors do not have a constant resistance. At least most students had a guess at classifying the type of component, but explanations were poor.

QUESTION 14

Nearly 50% of students gained half marks. Students found the concepts difficult to comprehend and explain. Those students who mentioned a difference in potential between the two siblings invariably constructed a good answer. Calculating the number of excess electrons was beyond many; a simple formula (no. of electrons = q/charge on electron) can be remembered to remedy this.

QUESTION 15

Conceptually this was a difficult question, with a few students scoring very well and many more scoring very poorly. Current electricity is problematic, especially when numbers are not involved. Students needed to compare the relative power output of each globe, after thinking about the comparative I and V values of the respective globes.

PART 4 – CRITERION 7

QUESTION 16

This question was a confidence booster for most students, with the naming of the organic compounds better answered than the inorganic formulae. Specifically:

- PF_3 has a *covalent molecular* structure, not covalent; many students wrote fluorine not fluoride.
- The most common fault when naming $PbCrO_4$ was the omission of the (II), and many could not correctly identify the chromate ion.
- Many students incorrectly numbered the carbon chain when naming organic structure 1, counting from left to right rather than correctly giving the triple bond end the lowest substitution. Both propyne and prop-1-yne were accepted as right.
- A common error when naming organic structure 2 was to fail to put the substituents in alphabetical order. Many students incorrectly interpreted the semi-structural formula and thought a double bond was present. Drawing the structure would potentially prevent such an error.

The electron dot diagram was well drawn in part (b), however, non-bonding electrons for fluorine atoms were sometimes omitted. Too many diagrams were poorly presented.

QUESTION 17

Students were quite successful in this question.

The most common fault made in part (b) was not realising the question required a net ionic equation. Half marks were awarded for a correct molecular or full ionic equations. Common errors were the omission of brackets for $Mg(OH)_2$, the omission of the 2 for $2OH^-$ on the LHS, and forgetting ion charges and state symbols. A surprising number of students provided an equation showing NaCl precipitating.

Often students did not realise the question in part (c) was asking for the names of the spectator ions from the precipitation reaction. Rather than giving Cl^- as one of the ions, Cl_2 (or even Cl_2^-) was suggested. The law of conservation of matter and the idea of balancing equations was often incorrectly mentioned.

QUESTION 18

Many students found this question difficult.

In part (a) (i) many did not realise that the subscript shows the number of atoms per molecule.

Only a few students gave clear, logical answers showing understanding of the difference between inter- and intra-molecular bonding, often mixing up the two. Actually naming the relevant bond as covalent rather than intra-molecular alleviates this problem. A surprising number of students thought that S_8 was a covalent network (or even ionic or metallic). Only a few students realised that more than one force/bond was present in the structure.

In part (b) most students chose the option of electrical conductivity. With reference to this choice, an explanation of the structures of sulphur and sodium and how they differed as regards their ability to conduct, was required. Other properties, such as malleability, were equally acceptable and marks awarded based on the merit of the explanation given.

A very common misconception in part (c) was that the given melting points of Na and S were high, and this lead to students contradicting themselves. This contradiction was ignored if students went on say the compound would have a high melting point, with good reasoning to follow. A numerical prediction was not required.

QUESTION 19

The first part of this question assessed the new course content regarding polar bonding in water. It was often not attempted and, when answered, the varied responses indicated the concept was poorly understood. A clear diagram showing the dipole moment of water or the intermolecular bonds between molecules was a necessary component of a correct answer. Disappointingly, the diagram of a water molecule often showed 1 hydrogen atom and 2 oxygen atoms.

Conversely, part (b) was well answered. To gain full marks students were required to discuss the bonding of graphite and reference it against the bonding in diamond. Frequently candidates only discussed the bonding of graphite.

QUESTION 20

Candidates are reminded that when there are alternative symbols used for elements that they should use these letters and not the actual symbols from the periodic table in their responses.

The formula of the most stable ion was surprisingly poorly done. Few candidates were able to identify that group 15 elements form 3- ions.

Whilst element ‘b’ (i.e. carbon) is the correct answer in the second dot point of part (a), markers also accepted element ‘a’ as a correct answer, since it is metallic, which according to the information sheet, will likely have a high melting point. However, candidates nearly universally answered ‘f’ to this question. Was this based upon the chemical stability of the noble gases rather than thinking about what the term gas means?

Part (b) was well answered; most candidates recognised that “g” was an electron donor and “e” a recipient. Unfortunately, there were a number of candidates who indicated that there was ‘sharing’ of electrons occurring, and they drew the matching electron dot diagram for this scenario.

The most frequent incorrect response in part (c) was to answer 'i', rather than 'e'. Candidates should ensure they study the trends of reactivity in the periodic table.

QUESTION 21

Using a dictionary would have helped the many candidates who confused the term isomer with isotope. There were varied responses to part (a) and markers were generous in their interpretations.

When answering part (b) most candidates correctly interpreted the first two dot points of information. This resulted in candidates recognising that the isomers must contain four carbon atoms and that A and B were unsaturated, whereas C was saturated. In contrast, the last dot point regarding the addition of hydrogen chloride gas generating one or two isomers challenged all but the strongest candidates. The most common misconception regarding the information provided was that A was an alkyne. Many students gained at least 2/3 for their efforts.

Candidates are generally well versed in the role of bromine to identify unsaturated and saturated hydrocarbons. The most common mistake in part (c) was to not read the question and omit the inclusion of a structural chemical equation.

PART 5 – CRITERION 8

Generally the first half of the paper was better answered than the second. In a number of questions students either answered well or had no idea. Success in stoichiometry requires a sound mathematical understanding of the content, and logical setting out. Many questions also required a good understanding of acids and bases, which is missing with many students. Unanswered questions in the latter section of Part 5 (Questions 26 and/or 27) may be evidence that the paper was too long.

QUESTION 22

Half the candidates obtained at least 5/7, indicating many are quite accomplished writing chemical equations.

Whilst most candidates balanced the equation in part (a), many simply stated that a gas would be produced when answering part (ii); this is not an observation. Markers were looking for observable characteristics such as bubbles being produced, solid metal disappearing, or heat produced.

The chemical equation in part (b) was quite well done, although candidates did not always read the information given carefully, writing ammonium carbonate as an aqueous solution rather than *(s)* and opting for H_2CO_3 as a product despite CO_2 and H_2O being stated as the products. States were too frequently omitted.

Part (b) (ii) asked for an explanation for the change in pH i.e. that concentration of hydrogen ions decrease therefore pH increases. Half marks were awarded for stating neutralisation, an increase in pH, or that ammonium carbonate was a base, without some explanation. Too many candidates assumed this question related to the reaction in (a) or stated that an acid was added to the solution, so more careful reading of the question is required. Students beginning their explanation with 'it' or 'they' needed to identify the antecedent.

Part (c) was reasonably well done although far too many candidates were unable to recall the formula for sulphuric acid and some used HCl or H_2S instead. A disturbing number of candidates wrote one of the products as $HOH_{(s)}$ or similar or attempted to add $H_{2(g)}$ as a product to balance the equation.

QUESTION 23

Part (a) was quite well answered. Marks were lost if candidates rounded 1.5 up to 2 as the expectation is that the ratios are doubled here. Some candidates also confused the molar mass of nitrogen and oxygen while still others assumed that oxide meant that only the oxygen needed to be calculated. The final part was also reasonably well done, although half marks were deducted if candidates failed to recognise that a result of 3.33 or similar meant that their calculation in (a) must have been an error.

QUESTION 24

Part (a) was reasonably well done, although some candidates doubled the copper molar mass and so lost half a mark. In part (b) many failed to understand the mole ratio relationship within compounds.

Part (c) was well done, although many simply used the anhydrous copper nitrate molar mass, failing to account for the additional water molecules in the hydrated compound.

QUESTION 25

Part (a) was very well done, apart from simple errors such as miscalculating M.

In part (b) students earned 1 mark for correctly using the 1:5 ratio to calculate n(O_2). Students needed to carry their calculated answer from part (a) for full marks; many students reverted to n(C_3H_8) = 0.5, the approximate value given by the examiner, and unnecessarily lost ½ mark. Many incorrectly multiplied by 5 twice (one in the ratio and one in the calculation of the molar mass).

Most students made part (c) much longer than necessary by calculating m(CO_2) and m(H_2O) from first principles rather than just adding masses already calculated. Some gave molar mass as mass.

QUESTION 26

Answers to part (a) revealed students have a misconception regarding neutralisation and dilution. Many students said NaOH was an acid rather than basic. This question was poorly done.

Part (b) was much better answered, but the majority did not finish by adding the c(Na^+) in NaOH to the c(Na^+) in sea water.

QUESTION 27

There was a general lack of acid/base vocabulary and understanding in answers to part (a). Students could not describe differences between words dilute/weak and concentrated/strong. This predictable question was not well done.

A lot of simple errors in calculations were evident in the solutions to parts (b) and (c). Many students incorrectly used the $C_1V_1 = C_2V_2$ formula without explanation, and hence lost valuable marks in part (a). If using this formula, students have to precede it by acknowledging the 1:1 ratio, stating n(NH_3) = n(HCl). In 'show that' questions students have to be more particular about their solution.

Part (b) was not well done. Students were confused because the calculation related to finding the % of ammonia in the undiluted solution, which had been diluted 10 times for the titration.

POSSIBLE SOLUTIONS

Physical Sciences 315118
TASC Exam, Nov 2018
Part 1 - Criterion 4

Q1 a) $^{26}_{12}Mg$

b) Atomic number = number of protons in nucleus (12)
Mass number = number of nucleons, protons+neutrons (for Mg this is 26)

c) $A_r = \frac{80}{100} \times 24 + \frac{10}{100} \times 25 + \frac{10}{100} \times 26$
$= 24.3$ AMU

d) Both Na and Mg are in period 3, with 3 electron shells. Na has 11 protons and Mg has 12 protons, hence Mg has greater electrostatic attraction between its nucleus and (outer) electron shells. This pulls electrons closer, making the radius of the Mg atom less than that of sodium.

Q2 a) Y and Z are isotopes of Sulfur (16 protons)

b) Group V or 15
Period 3

c) 2

d) Prediction - no stable ions
Explanation - none have full outer shells. Y needs 2 electrons → S^{2-}, Z needs 1 → S^{2-}, X needs 3 electrons → P^{3-}

Q3 a) gamma
alpha

b) Radium has a shorter half live so more atoms decay each second for a given amount of element.

c) α and γ rays are ionising. Microwaves from mobile phones are non-ionising.

d) Radiation decreases as distance increases as rays spread out from the source.
Ingesting particles of radioisotopes allows them to decay inside your body where the radiation can ionise surrounding cells.

Q4
a) $^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U$

b) $Y = ^{0}_{-1}\beta$ a beta particle
$Z = ^{0}_{0}\gamma$ gamma ray or $^{0}_{0}\bar{\nu}$ antineutrino

c) $T_{1/2}$ is the same as $^{239}_{93}Np$ as reacting with oxygen involves electron transfer. There is no change in the nucleus which retains its radioactive properties.

Q5 9 months = $\frac{9}{12} = 0.75$ years

a) $3 \div 0.75 = 4$ half lives
$1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8} \rightarrow \frac{1}{16}$
1 2 3 4 $\times T_{1/2}$
$\frac{1}{16}$ of the radioisotope remains

b) i) The background radiation count needs to be subtracted to calculate the counts coming from the radioisotope

(ii) initially $3432 - 102 = 3330$ cts
after $1 \times T_{1/2}$ $3330 \rightarrow 1665$
Expected Reading
$= 1665 + 102 = 1767$ counts in 300 sec

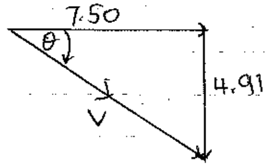
iii) Radioactive decay is random and spontaneous, so predictions are only estimates of actual counts.

Part 2 - CRITERION 5

Q6 a) speed = $\frac{distance}{time}$
(runner) = $\frac{5000\,m}{20 \times 60\,s} = 4.17\,ms^{-1}$
(rower) $\frac{16.0\,kmh^{-1}}{3.6} = 4.44\,ms^{-1}$
Rower has greater avg speed

b) $v = s/t = \frac{140}{20 \times 60}$
$= 0.117\,ms^{-1}$ East

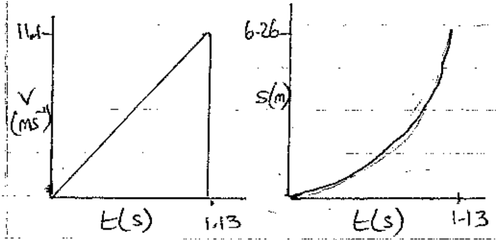
Q7
a)



b) $v^2 = 4.91^2 + 7.50^2$
$v = \sqrt{80.36} = 8.96\,ms^{-1}$
$\tan\theta = \frac{4.91}{7.50} = 0.6547$
$\theta = 33.2°$
v is $8.96\,ms^{-1}$ at 33.2° to horizon

c) $s = ut + \frac{1}{2}at^2$ $t = 1.13$
$= 0 + \frac{1}{2} \times 9.81 \times 1.13^2$ $a = 9.81$
$= 6.26\,m$ $u_v = 0$
Stone was thrown from 6.26 m above the ground.

d)



Q8

a) The ball is at the top of its flight, about to fall back down.

b) The gradient of v-t graph is acceleration. When falling $a = 9.81$ and is constant (with no air resistance)

c) $s =$ area v-t graph

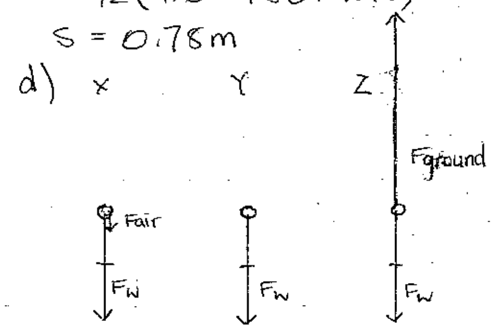
$= \frac{1}{2}bh$ for 3 triangles

$= \frac{1}{2}[0.4 \times 4 + 0.4 \times {}^{-}3.9 + 0.39 \times 3.8]$

$= \frac{1}{2}(1.6 - 1.56 + 1.48)$

$s = 0.78\text{m}$

d)



Q9

a) NO - Drag is the force air applies to the spacecraft. Its reaction pair is the force the sp.craft applies to air. Weight is the force earth applies to the sp.craft. Its reaction pair is the force the sp.craft applies to earth.

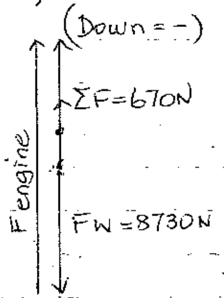
Q9b) $F_{drag} > F_{weight}$. There is a net force up so according to NL2 acceleration will be in the upwards direction and the spacecraft will slow down as it travels through the atmosphere.

c) If the astronaut is secured his motion is tied to that of the spacecraft. Unsecured he would be subject to inertia (NL1) and bang against the side of the spacecraft when it accelerates as his motion would continue until acted on by an external force.

d) $F_W = mg = 8.90 \times 9.81$

$= 8.73 \times 10^3\text{N}$ down

e)



$\Sigma F = F_{engine} + F_W$

$670 = F_e + {}^{-}8730$

$F_{engine} = 670 + 8730$

$= 9400\text{N}$

Engine's force is $9.40 \times 10^3\text{N}$ up

Q9 continued

f) $\Sigma F = ma$ (down -)

$670 = 890a$

$a = {}^{670}/_{890} = 0.753\text{ms}^{-2}$

$u = -5.50\text{ ms}^{-1}$

$t = 3.50\text{s}$

$v = u + at$

$v = {}^{-}5.50 + 0.753 \times 3.50$

$v = -2.86\text{ ms}^{-1}$ (2.86ms^{-1} down)

This is less than the required 3ms^{-1} so YES the engines will reduce speed sufficiently.

Q10

a) $u = 0$

$v = 32.0\text{ms}^{-1}$

$a = 3.48 \times 10^3 \text{ms}^{-2}$

$v^2 = u^2 + 2as$

$32.0^2 = 0^2 + 2 \times 3.48 \times 10^3 s$

$s = \frac{32.0^2}{2 \times 3.48 \times 10^3}$

$s = 0.147\text{ m}$ (14.7 cm)

b) $F = ma$

$= 0.440 \times 3.48 \times 10^3$

$F = 1531\text{ N}$

$\approx 1500\text{N}$

c) $\Delta p = m\Delta v = m(v - u)$

$= 0.440(32.0 - 0)$

$= 14.1\text{ kgms}^{-1}$ East

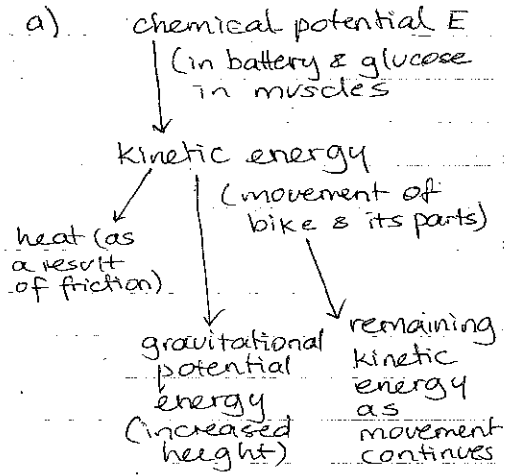
d) $F = \Delta p/t$ $t = 14.1/1531$

$1531 = 14.1/t$ $t = 0.00921\text{s}$

Part 3 - CRITERION 6.

Q11

a)



b) $E_K = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 80 \times 6.70^2$

$= 1.80 \times 10^3\text{J}$

c) $E_T = E_K + E_P$

$E_P = mgh = 80 \times 9.81 \times 3.00$

$= 2.35 \times 10^3\text{J}$

$E_T = (1.80 + 2.35) \times 10^3$

$= 4.15 \times 10^3\text{ J}$

$E_T \approx 4000\text{ J}$

d) $P_{motor} = W/t = 3700/12.5$

$= 296\text{ W}$

e) $W_{TOTAL} = W_{USEFUL} + W_{against\ FRICTION}$

$W_{useful} =$ Energy gained.

$= 4150\text{ J}$

$W_{TOTAL} = 5300 + 3700 = 9000\text{J}$

$W_{FRICTION} = 9000 - 4150 = 4850\text{J}$

$W = Fs$, $F_{FR} = \frac{4850}{50.0} = 97\text{N}$ against motion

$s = 50.0\text{m}$

Q11 continued

f) capacity = 0.418 × 1000 × 3600 J

= 1.50×10^6 J

E used = 3700 J

% used = $\frac{3700}{1.5 \times 10^6} \times 100\%$

= 0.25% of capacity

Q12 a) $\Sigma p_i = m_x v_x + m_y v_y$ (West / −)

= 0.0610 × 0.320

+ 0.092 × −0.620

= −0.0375 or

3.75×10^{-2} kgms^{-1} West

b) $\Sigma p_i = \Sigma p_f$ cons of momentum

−0.0375 = $m_{x+y} v_{x+y}$

−0.0375 = (0.0610 + 0.0920) v

$\frac{-0.0375}{0.153}$ = v

v = −0.245 ms^{-1}

V carriages is 0.245 ms^{-1} West

c) Inelastic collisions conserve momentum, but do not conserve energy of motion. ie some kinetic energy is lost in deformation, as heat or noise.

Q13 a) $P = \frac{V^2}{R}$

∴ $R = \frac{V^2}{P} = \frac{3^2}{2.5}$

R = 3.6 Ω

b) V = IR

∴ $R = \frac{V}{I} = \frac{1.5}{0.530}$

R = 2.83 Ω

c) non-ohmic

The resistance is not constant so the current is not proportional to voltage.

d) Filament lightbulbs are non-ohmic.

Q14

a) $q = -42 \times 10^{-6}$ C

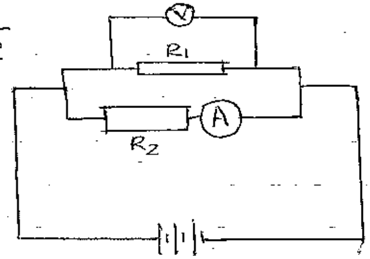
$e = -1.6 \times 10^{-19}$ C

no of electrons = $\frac{-42 \times 10^{-6}}{-1.6 \times 10^{-19}} = 2.6 \times 10^{14}$ electrons

b) She has a negative charge, her neutral brother is relatively positive so charge will flow from her to him. They will feel this 'spark' as current flows.

Q15

a)



b) R_1 will be dimmer than R_2. As current through both resistors is the same and V = IR ∴ greater resistance gives R_2 a larger energy drop and R_1 will have less energy to convert to light.

c) R_1 will be dimmer than in circuit 2 as the parallel circuit supplies the same voltage to both bulbs, ie greater V for R_1 than when it is sharing voltage with R_2

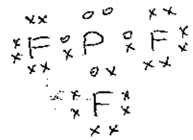
d) The battery will last longer in circuit 1 as circuit 2 draws more current in order to supply the higher voltages to each bulb.

Part 4 CRITERION 7

Q16 a)

phosphorus trifluoride	covalent molecular
Lead II chromate	ionic lattice
3-chloropropyne	
3-bromo-2-methylpentane	

b)



Q17 a)

A	yes
B	yes
C	no

b) 2 NaOH(aq) + $MgCl_{2(aq)}$ → $Mg(OH)_{2(s)}$ + 2NaCl(aq)

Net ionic:

$2OH^-_{(aq)} + Mg^{2+}_{(aq)} \rightarrow Mg(OH)_{2(s)}$

c) spectator ions: Na^+, Cl^-

Q18 a(i) There are 8 atoms of sulfur in the S_8 molecule.

(ii)

intra-molecular	strong	atoms
inter-molecular	weak	molecules

Q18 continued.

b) property: conductivity

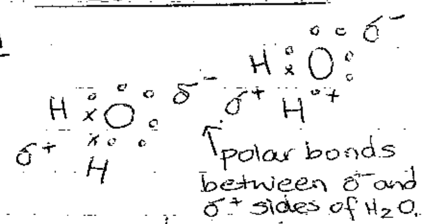
explanation: Sulfur will not conduct in any state as it has no free charges having all electrons bound in the covalent molecular structure. Sodium's metallic lattice has mobile, delocalised electrons which will conduct electricity in solid and molten states.

c) prediction: the melting point will be higher

explanation: sodium and sulfur (metal & non-metal) form an ionic compound with high melting point due to the strong electrostatic forces holding Na^+ and S^{2-} ions together. It takes a lot of thermal energy to break these bonds.

Q19

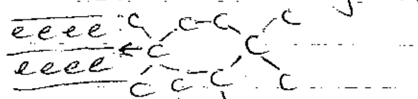
a)



Polar bonds between water molecules require more energy to break, giving water a higher melting point that a similar sized non-polar molecule which would have only weak intermolecular forces holding the molecules together, ie be a gas at Room temp

b)

Graphite's structure is a lattice of 2D layers of carbon with delocalised electrons between the layers.



The layers move apart easily as the forces holding them are weaker than the forces within the 2D lattice. This makes graphite softer than diamond which has a rigid 3D structure with strong bonds between all atoms.

Q20

a) C^{3-}

b

b) g will lose an electron to form g^+ ion, e will gain an electron to form e^-.

g^+ and e^- bond via electrostatic attraction to form an ionic compound.

c) e

Q21

a) Isomers are molecules with the same formula but different structures.

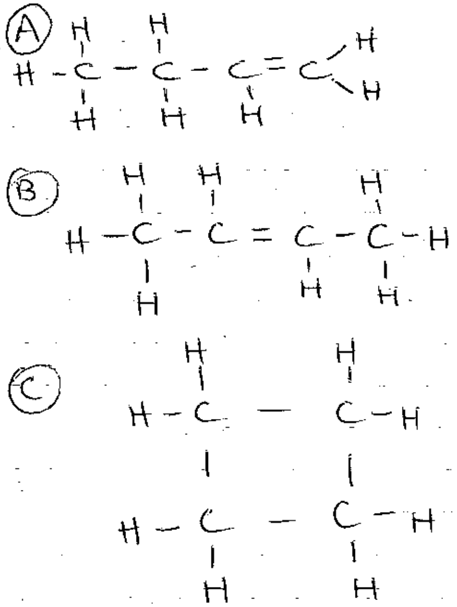
b)

- $4CO_2$ in combustion means C_4
- Br reaction means 2 unsaturated, 1 is saturated $\therefore C_4H_8$
- HCl reaction means Cl bond varies so B is symmetrical

→ C = cycloalkane

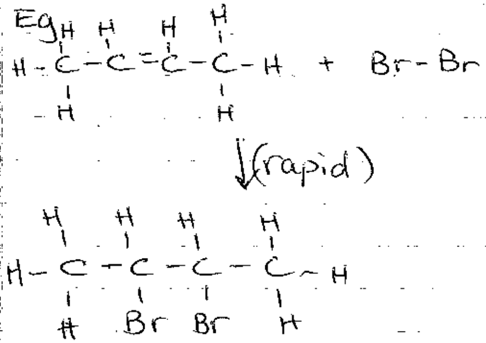
B = symmetrical alkene

C = no symmetry



c) Bromine reacts rapidly with unsaturated compounds, but only slowly in the presence of a catalyst with saturated compounds.

Eg



Part 5 CRITERION 8

Q22 a)

i) $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$

ii) • the metal will dissolve
• gas will be generated

b)(i)

$(NH_4)_2CO_{3(s)} + HCl_{(aq)} \rightarrow NH_4Cl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

(ii) H^+/HCl levels decrease as the carbonate reacts and basic NH_4^+ ions are produced. Hence pH will increase.

c)

$Ni(OH)_{2(s)} + H_2SO_{4(aq)} \rightarrow NiSO_{4(aq)} + 2H_2O_{(l)}$

Q23 a) N : O

$n = \frac{m}{M} \rightarrow \frac{36.8\,g}{14.01} : \frac{63.2\,g}{16.00}$

$2.63 : 3.95$

$= 1 : 1.5$

$\therefore N_2O_3$

b)

$M_{N_2O_3} = 2\times14.01 + 3\times16.0$
$= 76.02\ g\,mol^{-1}$

$\frac{152.0}{76.02} = 2$

$\therefore 2[N_2O_3] = N_4O_6$

Q24

a) $M_{Cu} = 63.54\ g\,mol^{-1}$

$\%\ Cu = \frac{63.54}{187.56} \times 100$
$= 33.9\%\ Cu$

b) $n_{NO_3^-} = 2 \times 0.140 = 0.280$ mol

$n_{H_2O} = 3 \times 0.140 = 0.420$ mol

c) $M_{Cu(NO_3)_2 \cdot 3H_2O} = 187.56 + 3M_{H_2O}$
$= 187.56 + 3\times18.016$
$= 241.61$

$m = nM$
$= 0.140 \times 241.61$
$m = 33.8\,g$ hydrated compound

Q25

a) $M_{C_3H_8} = 3\times12.01 + 8\times1.008$
$= 44.09\ g\,mol^{-1}$

$n = m/M = \frac{21.0}{44.09} = 0.476$ mol

$\simeq 0.5$ mol propane

b) $n_{O_2} = 5 \times n_{C_3H_8}$
$= 5 \times 0.476$
$= 2.38$ mol O_2

$m = nM = 2.38 \times 2\times16.00$
$= 76.2\ g\ O_2$ req'd

c) mass products = mass reactants
$= m_{C_3H_8} + m_{O_2} = 21.0 + 76.2$
$= 97.2\,g$

Q26

a) neutralisation is the result of acid-base reactions. Seawater is basic with pH 8.1, caustic soda is also basic so no neutralisation will occur when they mix.

b) $M_{NaOH} = 22.99 + 16.0 + 1.008$
$= 40.0\ g\,mol^{-1}$

$n(20\,g\ NaOH) = m/M = \frac{20.0}{40.0}$
$= 0.500$ mol

$c_{Na^+} = n/V = \frac{0.500}{2.00} = 0.250$ mol/L

new concentration
$= 0.250 + 0.469$
$= 0.719\ mol\,L^{-1}$

Q27

a) This is a concentrated solution of a weak base.
• 15 mol L^{-1} is a high number of ions per litre of water hence concentrated
• Ammonia is a base as $NH_{3(g)} + H_2O_{(l)} \rightarrow NH_{4(aq)}^+ + OH^-_{(aq)}$ it is a proton acceptor when it dissolves.
• Ammonia's dissociation in the above reaction is only partial, hence weak base.

b) $n_{HCl} = cV = 0.425 \times 0.0219$
$= 9.31\times10^{-3}$ mol

$n_{HCl} : n_{NH_3} = 1:1$

$\therefore C_{NaOH} = n/V = \frac{9.31\times10^{-3}}{0.0200}$

$= 0.465\ mol\,L^{-1}$

$\simeq 0.5\ mol\,L^{-1}\ NH_3$ soln.

c)

$C(\text{undiluted } NH_3) = 10 \times 0.465$
$= 4.65\ mol\,L^{-1}$

$M_{NH_3} = 14.01 + 3\times1.008$
$= 17.03\ g\,mol^{-1}$

$m_{NH_3} = nM = 4.65 \times 17.03$
$= 79.2\,g$ in a litre

$\%\ mass = \frac{79.2\,g}{1000\,g} \times 100$
$= 7.92\%$

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