Neap:

Trial Examination 2015

VCE Chemistry Unit 1

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

1	A	B	**C**	D	11	**A**	B	C	D
2	A	B	C	**D**	12	A	B	C	**D**
3	**A**	B	C	D	13	A	**B**	C	D
4	A	B	C	**D**	14	A	**B**	C	D
5	A	**B**	C	D	15	**A**	B	C	D
6	**A**	B	C	D	16	A	B	**C**	D
7	A	B	**C**	D	17	**A**	B	C	D
8	A	**B**	C	D	18	A	B	**C**	D
9	A	**B**	C	D	19	A	B	C	**D**
10	A	B	C	**D**	20	A	B	**C**	D

Question 1 C

Isotopic atoms of an element do not have identical mass, and so **A** is incorrect. Atoms are composed of subatomic particles, so **B** is incorrect. The most stable ratio of elements in a compound varies between compounds, so **D** is incorrect. **C** gives the modern accepted definition of a compound and is therefore the required answer.

Question 2 D

Each compound is composed of a metal and non-metal, so ionic bonding can be assumed due to electron transfer between the atoms. **A** and **C** are accurate, and so are not the required answers. The strength of the forces holding the ions to each other is reflected in the melting point, and so the bonds in MgO are stronger. **B** is not the required answer. The electron configurations of the ions present in each compound are identical ($1s^2 2s^2 2p^6$) and so this cannot account for the difference in melting temperatures. Thus **D** is not a reasonable statement and so is the required answer.

Question 3 A

Isotopes of an element have the same number of electrons, and hence the same electronic configuration as each other. **A** is the required response.

Question 4 D

The relevant relative atomic mass figures, shown in the brackets, are:

A. Ca (40.0), Ba (137.3), average (88.7), Sr (87.6)

B. Li (6.9), K (39.1), average (23.0), Na (23.0)

C. Cl (35.5), I (126.9), average (81.2), Br (79.9)

D. B (10.8), Ga (69.7), average (40.3), Al (27.0)

The average does not match the middle value in alternative **D**.

Question 5 B

The idea of electron arrangement in shells was postulated by Bohr in the early 1900s. Mendeleev predates this, and so he could not have used electron configuration as a basis for his table. Statement **B** is incorrect and is therefore the required response. Mendeleev placed elements in vertical columns based on their similarities in chemical properties. The statements in **A**, **C** and **D** are correct.

Question 6 A

X is likely to lose the three electrons in the third shell and form X^{3+} ions. Y needs one electron to complete the p-subshell and form Y^- ions. The compound formed is likely to be XY_3 and so **A** is the correct answer.

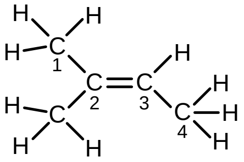
Question 7 C

Malleability is a property of metals. X is a metal in group 13 ($3s^2 3p^1$), whereas Y is a non-metal in group 17 ($4s^2 4p^5$) and Z is a non-metal in group 15 ($3s^2 3p^3$). Y and Z would not be expected to be malleable.

Question 8 B

The first three electrons removed require little energy, whereas the next two require a much larger input of energy. Thus it can be assumed that these three electrons are the only electrons in the outer shell, so the element is in group 13.

Question 9 B



The longest unbranched chain contains 4 carbon atoms with one double bond and so the name is based on butene. The double bond is between carbons 2 and 3 and thus the name is but-2-ene. A methyl group is attached on the second carbon and so 2-methylbut-2-ene is the correct answer.

Question 10 D

The molecular formulas of the compounds are:

I: C_5H_{10}

II: C_6H_{12}

III: C_5H_9O

IV: C_5H_{10}

Only compounds I and IV have the same molecular formula and so these are isomers of the same compound.

Question 11 A

Electronegativity (electron-attracting power) decreases down a group due to the increasing distance between the nuclear charge and the outer-shell electrons (and hence decreased attraction for electrons), so **A** is correct. Core charge increases across a period due to increasing nuclear charge, so **B** is not correct. Metallic character increases moving down a group due to the increasing distance between the nuclear charge and the outer-shell electrons (and hence increased ease of removal of the electrons), so **C** is not correct. Ionisation energy increases across a period due to increasing nuclear charge and decreasing atomic radii, so **D** is not correct.

Question 12 D

$A_r(Pb) = 207.2$

The mass number of the missing isotope cannot be 205 because it is not mathematically possible to produce a weighted mean of greater than 207 if all of the relative isotopic masses are below 207. **A** and **B** are not correct. Ignoring lead-204, the average of the other two isotopes is approximately 206.5. To move this mean to 207.2 would require the heaviest isotope to have a relative abundance greater than 3. **C** is not correct and **D** is the required answer. Approximate calculations are:

$$A_r(Pb) = \frac{(1.5 \times 204) + (8.5 \times 206) + (7.5 \times 207) + (18 \times 208)}{35.5} = 207.1$$

and

$$A_r(Pb) = \frac{(1.5 \times 204) + (8.5 \times 206) + (7.5 \times 207) + (3 \times 208)}{20.5} = 206.5$$

Question 13 B

The atom loses its outer shell of electrons when the ion forms, and so the ion will have a smaller radius than the atom. **A** and **C** are incorrect. Chemical properties depend on electron configuration. The ion and atom differ in number of electrons, and so will have different chemical properties. **C** and **D** are incorrect. Neither atomic number nor mass number are affected by loss of electrons to form ions, and so **B** is the required response.

Question 14 B

The simple metallic bonding model is a regular array of cations with delocalised electrons moving freely throughout. Metal alloys usually have lower electrical conductivity as the lattice has been disrupted by the introduction of ions or atoms of differing sizes; that is, delocalised electrons cannot flow freely throughout the lattice. Statement I can be explained using the model. Metallic bonding is strong bonding and so metals must be heated to high temperatures to become liquid. Mercury does not fit this characteristic and so statement II cannot be readily explained using the simple model. Conduction of heat occurs due to the moving electrons bumping into each other and the metal cations, so the energy is quickly transmitted throughout the lattice. Differences in heat conduction (statement III) cannot be explained using the simple model.

Question 15 A

Surface energy is related to the energy required to break bonds in order to form a new surface. Magnesium oxide has the strongest interparticle bonding (ionic bonding). Water molecules are held to each other by hydrogen bonding, which is stronger than the dispersion forces holding non-polar octane molecules to each other.

Question 16 C

$$M = \frac{m}{n} = \frac{28.19}{0.320} = 88.1 \text{ g mol}^{-1}$$

This is the molar mass and so the relative molecular mass of the compound is 88.1 (with no units). Statement I is correct. The empirical formula is C_2H_4O which has a relative mass of 44. Thus the molecular formula is $C_4H_8O_2$. Statement II is correct and statement III is incorrect.

Question 17 A

$$n(CS_2) = \frac{m}{M} = \frac{33}{76.2} = 0.433 \text{ mol}$$

$$n(C) = n(CS_2) = 0.433 \text{ mol}$$

$$m(C) = n \times M = 0.433 \times 12 = 5.2 \text{ g}$$

Question 18 C

Carbon disulfide is formed from two non-metals and should exist as molecules with covalent bonding. These molecules will be linear and non-polar, hence intermolecular bonding will be by weak dispersion forces. CS_2 will not conduct electricity as there are no free charged particles present, so **A** is incorrect. **B** is also incorrect. **C** is correct. C, Si, SiO_2 and SiC are covalent network solids, while CS_2 is not. **D** is incorrect.

Question 19 D

Complete combustion involves reaction with enough oxygen so that only carbon dioxide and water are formed.

Question 20 C

Quenching involves heating a metal to red-hot and quickly cooling, usually by plunging into water. A harder but more brittle metal is the result. So **A**, **B** and **D** are incorrect. Annealing involves cooling the heated metal slowly to produce larger metal crystals, which results in a softer metal that is more easily worked. **C** is the correct answer.

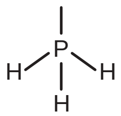
SECTION B: SHORT-ANSWER QUESTIONS

Question 1 (9 marks)

a. The group 16 elements have the electron configuration of s^2p^4 and so 'need' two electrons to complete the octet; that is, one electron is shared by each of two hydrogen atoms. 1 mark

The group 15 elements 'need' to share three electrons to complete the octet and so there are three hydrogen atoms in each of these hydrides. 1 mark

b. i.



1 mark

ii. trigonal pyramid 1 mark

c. The hydrides in the graph are polar molecules. Thus they have dipole-dipole bonding holding the molecules to each other. 1 mark

The group 18 elements have only dispersion forces holding the atoms to each other. 1 mark

The stronger dipole-dipole intermolecular bonding in the hydrides requires more energy to disrupt than the very weak dispersion forces in the group 18 elements. This results in higher boiling points for the hydrides. 1 mark

d. The intermolecular bonding in water and ammonia is hydrogen bonding. 1 mark

This hydrogen bonding is stronger than the dipole-dipole bonding in the other hydrides, leading to a higher than expected boiling point for ammonia and water. 1 mark

Question 2 (17 marks)

a. i. $\%\text{Na} = \frac{2 \times 23.0}{106.0} \times 100 = 43.4\%$ 1 mark

ii. $2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O(l)$ 1 mark

b. $n(H_2SO_4) = \frac{m}{M} = \frac{10.0}{98.1} = 0.102 \text{ mol}$ 1 mark

There are 7 atoms per molecule of H_2SO_4 and so:

$n(\text{atoms}) = 7 \times 0.102 = 0.714$ mol 1 mark

number of atoms = n x $N_A = 0.714 \times 6.02 \times 10^{23} = 4.30 \times 10^{23}$ atoms 1 mark

c. Solid copper oxide consists of a lattice of copper ions and oxide ions. 1 mark

As these ions are held tightly in the lattice by ionic bonding, no electric current will flow through the solid. 1 mark

Once molten, the ions can move freely and so the molten liquid will conduct electricity. 1 mark

d. In 100 g of the compound there is 27.8 g of N and so 71.2 g of Mg.

$n(\text{Mg}) : n(\text{N}) = \frac{72.2}{24.3} : \frac{27.8}{14.0} = 2.97 : 1.99 = 1.49 : 1 = 3 : 2$ 1 mark

empirical formula of compound = Mg_3N_2 1 mark

e. **i.** The mass of the atom is compared to carbon-12, which is given the mass of 12 exactly. As it is relative, there are no units. 1 mark

ii. Elements in the Periodic Table are ordered in increasing atomic number, not increasing atomic mass. For potassium, Z = 19, whereas for argon, Z = 18. 1 mark

iii. $^{38}_{18}Ar$ 1 mark

iv. $^{39}_{19}K^{+}$ or $^{40}_{20}Ca^{2+}$ 1 mark

v. The argon atom and the isoelectronic ion both have three shells of electrons containing a total of 18 electrons. 1 mark

The greater nuclear charge of the cation will draw the shells of electrons closer to it than the lesser nuclear charge in argon will, and so the cation would be expected to have the smaller radius. 1 mark

vi. 12 *(6 in the 2p orbitals and 6 in the 3p orbitals)* 1 mark

Question 3 (14 marks)

a. **i.** different structural forms of the same element 1 mark

ii. high boiling point 1 mark

b. **i.** $n(C_{60}) = \frac{m}{M} = \frac{500}{12 \times 60} = 0.694$ mol 1 mark

ii. Each carbon atom is bonded to only three other carbon atoms in the structure, forming three covalent bonds. 1 mark

As there are four electrons in a carbon atom's outer shell, one electron per atom will not be shared and will become delocalised, allowing electric current to be conducted. 1 mark

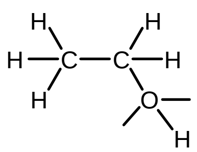
c. **i.** There are weak dispersion forces holding the layers to each other in the graphite structure. 1 mark

These attractive forces can easily be overcome using adhesive tape to peel off a layer. 1 mark

ii. Steel has strength from the attraction of the three-dimensional array of iron cations to delocalised electrons moving throughout the lattice. 1 mark

Carbon atoms placed between the iron cations impede the iron cations moving over each other when placed under tension, and so the strength of the steel is enhanced. 1 mark

d. **i.**



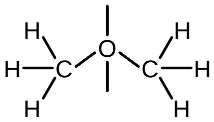
1 mark

ii. 1,2-dibromoethane 1 mark

iii. addition 1 mark

iv. C_6H_{12} 1 mark

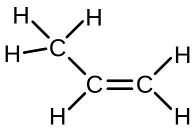
v.



1 mark

Question 4 (10 marks)

a. **i.**



1 mark

ii. polypropene 1 mark

iii. In polymer S the methyl groups are all on the same side of the molecule, and so the chains can pack close to each other. This leads to stronger dispersion forces, and the intermolecular bonding is more intense than in the other polymers. 1 mark

In polymer T there is no pattern in the placement of the methyl groups, and so the chains cannot pack as closely. Thus the interchain/intermolecular bonding is weaker. 1 mark

iv. Heat each sample gradually under the same conditions. 1 mark

The sample which takes the longest time to become pliable enough to mould is the polymer with the strongest intermolecular bonding. 1 mark

b. **i.** the carbon remaining from the decomposition of the polymer 1 mark

ii. If the plastic is heated to a lower temperature and it softens, then it is classified as a thermoplastic. 1 mark

All plastics will decompose if heated to high temperatures, so this plastic cannot be classified as a thermoplastic or thermosetting plastic using the information provided. 1 mark

iii. *Any one of:*

- increase the polymer chain length
- using an additive, cross link the polymer chains

1 mark

