Neap:

Trial Examination 2011

# VCE Chemistry Unit 1

Written Examination

## Suggested Solutions

### SECTION A: MULTIPLE-CHOICE QUESTIONS

| | | | | |
|---|---|---|---|---|
| 1 | **A** | B | C | D |
| 2 | A | **B** | C | D |
| 3 | **A** | B | C | D |
| 4 | A | B | C | **D** |
| 5 | A | **B** | C | D |
| 6 | A | B | **C** | D |
| 7 | A | **B** | C | D |
| 8 | A | **B** | C | D |
| 9 | A | B | **C** | D |
| 10 | A | **B** | C | D |

| | | | | |
|---|---|---|---|---|
| 11 | A | B | **C** | D |
| 12 | A | B | C | **D** |
| 13 | **A** | B | C | D |
| 14 | **A** | B | C | D |
| 15 | A | B | **C** | D |
| 16 | A | B | C | **D** |
| 17 | A | B | C | **D** |
| 18 | A | B | **C** | D |
| 19 | A | B | C | **D** |
| 20 | **A** | B | C | D |



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**Question 1 A**

Only metals and the covalent substance graphite will conduct electricity when solid or molten. Ionic substances will only conduct when molten. Solid graphite will not melt using a Bunsen burner, whereas some metals and ionic compounds will. Thus, the bonding present in the substance could be metallic or ionic.

**Question 2 B**

RAM = (RIM × abundance fraction)

$207.2 = x \times 1.4 + (x + 2) \times 24.1 + (x + 3) \times 22.1 + (x + 4) \times 52.4$

Solving for $x$ gives 204.

**Question 3 A**

Lengthening chains increases the overall strength of dispersion forces between them, while polar groups allow for stronger dipole-dipole bonds to form between chains. Cross-linking involves the formation of strong covalent bonds between chains. These effects will increase polymer strength. Branching polymer chains has the effect of decreasing the strength of forces between the chains. This is due to the loose packing of the chains, as the branched structure means that chains cannot be moved as close together as can 'straight' chains. Hence **A** is the required response.

**Question 4 D**

In each incorrect alternative, there is at least one molecule's shape which does not appear in the list: alternative **A** – $OF_2$ (V-shaped); alternative **B** – $H_2O$ (V-shaped); alternative **C** – $SF_6$ (octahedral). All the shapes appear in the list for alternative **D**: HCl (linear), $PH_3$ (triangular pyramidal) and $SiH_4$ (tetrahedral), so **D** is the required response.

**Question 5 B**

In the quantum mechanical model of the atom, for the shell $n$, the number of subshells is $n$, the number of orbitals is $n^2$ and the maximum number of electrons is $2n^2$. Thus the values for the fourth shell are 4, 16 and 32 respectively. Alternative **B** is the correct response.

**Question 6 C**

Members of a homologous series have the same general formula, e.g. $C_nH_{2n+2}$ for alkanes. They do not have the same empirical formulas or the same molecular formulas, e.g. $CH_4$ for methane and $CH_3/C_2H_6$ for ethane, hence **A** and **B** are incorrect. The members of a homologous series show a gradual change in physical properties, e.g. increasing boiling points for alkanes, but all show similar chemical properties, e.g. addition reaction of alkenes with bromine. Hence **C** is the required response.

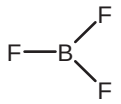
**Question 7 B**

The ratio by mass of each element in the compounds is shown in brackets: $Na_2O$ (46:16); $SO_2$ (32:32); $CO_2$ (12:32); NO (14:16). Alternative **B** is the correct response.

**Question 8 B**

The trigonal planar structural formula for $BF_3$ is shown below.




The B-F bond is polar due to the difference in electronegativity of the two elements. The molecule however is non-polar due to the symmetry of the molecule and the absence of an overall dipole in the molecule.

**Question 9 C**

The mass of magnesium used = $16.2 - 13.8 = 2.4$ g. As the empirical formula of the compound is MgO,

$$n(\text{O}) = n(\text{Mg}) = \frac{m}{M} = \frac{2.4}{24.3} = 0.099 \text{ mol}$$

$$n(\text{MgO}) = n(\text{O}) = n(\text{Mg})$$

$$m(\text{MgO}) = n \times M = 0.099 \times (24.3 + 16) = 3.98 \text{ g}$$

**Question 10 B**

In the empirical formula of $Mg_{10}O_9$, the mass of oxygen is being underestimated. In the experiment, the mass of oxygen is determined by subtracting the mass of magnesium used from the total mass of magnesium oxide produced. Thus any error resulting in less magnesium oxide being recovered will give the incorrect result here. Losing some oxide from the crucible would lead to a lower mass of magnesium oxide. Thus statement I would explain the result. For statement II, a larger mass of magnesium would produce a larger mass of magnesium oxide and should have no effect on the result. If there was incomplete combustion of the magnesium, the final mass of the magnesium oxide would be less than if complete combustion had occurred. Statement III is thus valid. Using a different crucible will not have any effect on the calculated mass of oxygen. The change given in statement IV is irrelevant. As either I or III would cause the underestimation of the mass of oxygen, alternative **B** is the required response.

**Question 11 C**

In the compound $X_2O_3$, the *X* ion will have a charge of +3. In $H_2Y$, the *Y* ion will have a charge of –2. Thus a stable compound will be likely with a formula of $X_2Y_3$.

**Question 12 D**

Only graphite is an allotrope of carbon and so alternative **A** is incorrect. For alternative **B**, although all the stated substances are hard, only graphite will conduct electricity. Silicon carbide and silicon dioxide are brittle, while graphite is slippery. All three have covalent bonds present, but graphite also has dispersion forces between the layers of covalently bonded carbon atoms. Thus **C** is incorrect. Graphite is a covalent layer lattice whereas silicon dioxide and silicon carbide are three dimensional covalent lattice structures. High temperatures are required to melt each of the covalent structures and so **D** is the required response.

**Question 13 A**

Statement I is accurate as there are insufficient hydrogen atoms in the hydrocarbon to produce all single bonds. Isomers would have the double bonds in different locations in the branched or unbranched hydrocarbon molecule. Statement II is accurate as a carbon chain with 3 carbon atoms can only be configured in a single arrangement. Statement III is not correct because the physical properties (e.g. boiling point) of isomers of a compound may differ, while their chemical properties are similar. **A** is the required answer as only statements I and II are valid.

**Question 14 A**

Alternative **B** gives the electronic configuration of a Group 2 element in its ground state. Alternative **C** gives the electronic configuration of a Group 14 element in its excited state. Alternative **D** gives the electronic configuration of a transition element in its ground state. Alternative **A** gives the electronic configuration of a Group 2 element in its excited state, its ground state configuration being $1s^2\ 2s^2\ 2p^6\ 3s^2$.

**Question 15 C**

The proportion of copper present in a sample of copper(II) oxide will be constant regardless of the method of synthesis. A larger mass of copper(II) oxide must have a larger mass of copper present. Thus the mass of copper will be greater than 9.84 g in sample 2.

**Question 16 D**

Rigid, thermosetting polymers have extensive covalent cross-links between the polymer chains in the structure. Therefore **D** is the required response.

**Question 17 D**

Homologous series *M* cannot be the alkenes as no alkene could have only one carbon atom per molecule as shown in the graph. In addition, alkenes have lower boiling points than their corresponding alkanes. Alternative **A** is incorrect. There is no valid reason why the series *M* must be similar to the alkanes or even contain only hydrogen and carbon. Thus alternative **B** is incorrect. The boiling points of the compounds in series *M* increase with the number of carbon atoms per molecule. This is due to the larger molecules having greater intermolecular forces of attraction between them. So alternative **C** is incorrect. Comparing each alkane with its counterpart in series *M*, the boiling point is significantly lower for the non-polar alkanes. It is likely that the difference in boiling points is due the presence of a polar function group in the compounds of series *M*. Alternative **D** is the required response.

**Question 18 C**

Mass of oxygen = 8.572 – 6.740 = 1.832 g

$$n(\mathrm{O}) = \frac{m}{M} = \frac{1.832}{16.0} = 0.1145 \text{ mol}$$

As the formula of compound is ZO, $n(\mathrm{Z}) = n(\mathrm{O})$

$$M(\mathrm{Z}) = \frac{m}{n} = \frac{6.740}{0.1145} = 58.86 \text{ g mol}^{-1}$$

**Question 19 D**

Methyl propanoate contains 4 carbon atoms, 8 hydrogen atoms and 2 oxygen atoms. Isomers of methyl propanoate must contain these same numbers of each atom type. Alternative **D** shows a compound containing 5 carbon atoms. This is not an isomer, and so is the required response.

**Question 20 A**

The plasticiser molecule fits between the carbon chains, holding them slightly further apart (**D** is correct). This causes the dispersion forces between the chains to decrease (**C** is correct) resulting in lower softening temperatures (**B** is correct). There will be no change in the nature of the covalent bonds holding the polymer chain together and so **A** is incorrect and is therefore the required response.

## SECTION B: SHORT-ANSWER QUESTIONS

### Question 1

**a.** **i.** increasing atomic mass 1 mark

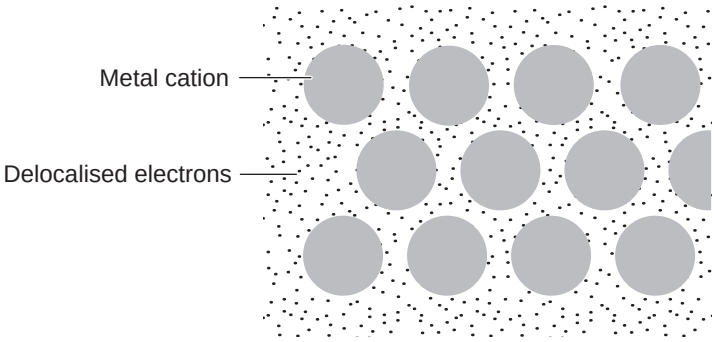
**ii.** He arranged the table according to his 'law of octaves' so that elements in the same vertical column had similar properties. 1 mark

To ensure elements which were obviously similar were kept in the same column, he put more than one element into a single space where necessary. 1 mark

**b.** **i.** transition metals OR d-block 1 mark

**ii.** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$ 1 mark

**iii.**




1 mark

Metals are thought to consist of an orderly array of cations surrounded by a 'sea' of delocalised electrons. 1 mark

If the metal is subjected to an electric field, the free-moving delocalised electrons will move between the electrodes, producing an electric current. 1 mark

**iv.** magnetism 1 mark

**c.** As the halogen diatomic molecules become larger moving from $F_2$ to $I_2$, the dispersion forces between molecules increase in strength. 1 mark

The larger intermolecular forces require more energy to disrupt and so the melting point of the halogens increases down Group 17. 1 mark

**d.**

| Property and sequence of elements | Change in the property | | |
|---|---|---|---|
| | increases | unchanged | decreases |
| **Atomic radii from N to Li (N, C, B, Be, Li)** | ✓ | | |
| **Electronegativity from Te to O (Te, Se, S, O)** | ✓ | | |
| **Number of electrons in the sequence Ar, $Cl^-$, $S^{2-}$** | | ✓ | |

3 marks

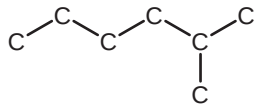
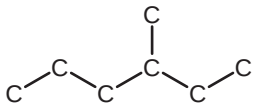
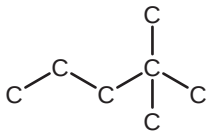
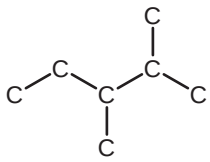
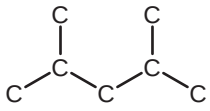
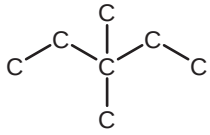
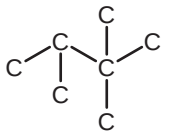
Total 14 marks

**Question 2**

**a.** **i.** $n(\text{C}):n(\text{H}) = \frac{84}{12}:\frac{16}{1} = 7:16$

The alkane is therefore $C_7H_{16}$ (heptane) 1 mark

**ii.** Any one of the following (note that only the carbon skeletons are shown here).

1 mark

**b.** **i.** Methane $(C_4H_{10}(g) \rightarrow C_3H_6(g) + CH_4(g))$ 1 mark

**ii.** Combustion of the hydrocarbons will occur if oxygen is present. 1 mark

**c.** $n(\text{C}_3\text{H}_6) = \frac{m}{M} = \frac{100 \times 1000}{42.0} = 2381 \text{ mol}$ 1 mark

$N(\text{C}_3\text{H}_6) = n \times N_A = 2381 \times 6.02 \times 10^{23} = 1.43 \times 10^{27}$ 1 mark

**d.** $\text{C}_3\text{H}_6 + \text{H}_2\text{O} \rightarrow \text{C}_3\text{H}_7\text{OH}$ 1 mark

**e.** The dispersion forces between both molecules will be of similar strength as the molecules are of roughly the same mass. 1 mark

The –OH group in ethanol will participate in hydrogen bonding between the ethanol molecules, holding the molecules to each other more strongly than by dispersion forces alone, 1 mark thus a higher temperature is needed to disrupt the bonding and so ethanol has the higher boiling point.

1 mark

Total 10 marks

**Question 3**

**a. i.** Each proton has a mass of 1 unit and, as a helium nucleus has 4 protons, its mass would be four times the mass of a hydrogen nucleus with its one proton (the mass of the electron being negligible). 1 mark

Each proton has a charge of +1 and each electron has a charge of –1, producing an overall charge for the helium nucleus of +2. 1 mark

**ii.** Any two of:

- Electrons are not located in the nucleus.
- Neutrons are not included in the model. (*Neutrons had not been discovered. These account for the disparity in mass between the hydrogen and helium nuclei*.)
- Helium has only two protons, not four.

2 marks

**b. i.** $^{234}_{90}\text{Th}$ 1 mark

**ii.** Thorium-X is an isotope of thorium. It was heavier than the other atoms in the sample as it contained more neutrons. 1 mark

**c. i.** Any two of:

- The atom has 11 electrons.
- The first electron removed requires little energy, the next 8 electrons require more energy, but about the same for each. The last two electrons require a large amount of energy for their removal.
- It can be deduced that there are three different energy levels or shells, each holding different numbers of electrons.

2 marks

**ii.** $Na^+$ 1 mark

Total 9 marks

**Question 4**

**a. i.** The presence of a carbon-carbon double bond. 1 mark

**ii.** $C_{14}H_{11}N$ 1 mark

**b. i.** $m(\text{N}) = \frac{14.0}{193} \times 1.55 = 0.112 \text{ g}$ 1 mark

**ii.** $n(C_{14}H_{11}N) = \frac{m}{M} = \frac{0.205}{193} = 1.06 \times 10^{-3} \text{ mol}$ 1 mark

**c.** No 1 mark

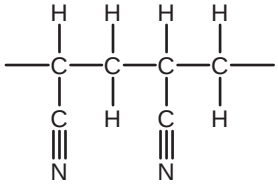
Polymers have a molecular structure. They do not contain freely moving charged particles and so would not be expected to conduct an electric current. 1 mark

**d.**

| Type of bond | Strength of bond compared with that of a carbon-carbon single covalent bond (*answer as greater than, less than or equal to*) | Length of bond compared with that of a carbon-carbon single covalent bond (*answer as longer then, shorter than or equal to*) |
|---|---|---|
| Carbon-carbon double covalent bond | greater than | shorter than |
| Carbon-carbon bond between the layers in graphite | less than | longer than |

2 marks

**e.**



2 marks
*1 mark for correct polymer form*
*1 mark for C-N triple bond*
Total 10 marks

**Question 5**

**a.** **i.** $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ 2 marks

*1 mark for correct formulas*
*1 mark for balancing and states*

**ii.** In a macrosize particle of zinc oxide, most of the ions are held within the lattice and are not exposed to the UV light. 1 mark

In a nanoparticle, the amount of surface area available for absorption of light is increased enormously compared to the same mass of a macrosize particle. This allows for more efficient absorption of light. 1 mark

**b.** Octane is a molecular substance containing covalently bonded molecules. Bonding between these molecules is by weak dispersion forces. 1 mark

This weak bonding accounts for the low surface energy. 1 mark

Diamond is a covalent network lattice with strong covalent bonds throughout. This strong bonding accounts for the high surface energy. 1 mark

Total 7 marks