Neap:

Trial Examination 2012

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

The formulas of compounds I and II are in the simplest ratio, whereas the ratios for compounds III and IV can be simplified to CH_2O and C_5H_4 respectively.

Question 2 C

Relevant calculations are:

$N(\text{O atoms}) = 3 \times N(SO_3 \text{ molecules}) = 3 \times 2.3 \times 10^{23} = 6.9 \times 10^{23}$

$n(\text{O}) = n(H_2O) = \frac{m}{M} = \frac{19}{18} \text{ mol}$

$N(\text{O atoms}) = n \times N_A = \frac{19}{18} \times 6.02 \times 10^{23} = 6.4 \times 10^{23}$

$N(\text{O atoms}) = n \times N_A = 0.95 \times 6.02 \times 10^{23} = 5.7 \times 10^{23}$

$n(\text{O}) = 2 \times n(O_2) = 2 \times 0.60 = 1.2 \text{ mol}$

$N(\text{O atoms}) = n \times N_A = 1.2 \times 6.02 \times 10^{23} = 7.2 \times 10^{23}$

The smallest number is 5.7×10^{23}, and so **C** is the required response.

Question 3 A

Thermosoftening plastics will soften with heating, thermosetting plastics will not. Thus alternative **A** is incorrect, and so is the required response. Thermosetting plastics have enough crosslinks between the chains to produce a rigid plastic which tends to be brittle and can withstand moderate temperatures without degradation. Alternative **B** is thus a correct statement, and so is not the answer required. All thermosetting plastics will char and burn if a high enough temperature is used. Alternative **C** is thus a correct statement, and so is not the answer required. Only thermosoftening plastics will soften with heat for remoulding to enable them to be recycled easily. Most thermosetting plastics are not recycled and end up in landfill. Alternative **D** is thus a correct statement, and so is not the answer required.

Question 4 B

Using comparison with butane, C_4H_{10}, it would be expected that Si_4H_{10} would have two different structures.

Question 5 C

In the metallic bonding model, cations are arranged in a lattice, with a 'sea' of delocalised electrons free to move throughout. Therefore statements **A** and **B** are incorrect. The delocalised electrons originate from the outer shell of metallic atoms, as these are weakly attracted to the nucleus. Inner shell electrons are attracted more strongly and do not become delocalised. Thus **D** is incorrect. Alternative **C** is the best description of the metallic bonding model.

Question 6 D

The metallic bonding model explains simple properties such as electrical conductivity, ductility, malleability and so on. It cannot explain the differences in these properties, nor the existence of magnetism in some metals.

Question 7 **B**

$$n(\text{Al}) = \frac{2}{3} \times n(\text{S})$$

$$m(\text{Al}) = n \times M = \frac{2}{3} \times 0.25 \times 27.0 = 4.5 \text{ g}$$

Question 8 **B**

SiO_2 is a covalent network lattice similar to that of diamond, therefore **C** and **D** are not correct. Each silicon atom is covalently bonded to four oxygen atoms. Each oxygen atom is covalently bonded to two silicon atoms to form the three-dimensional covalent lattice. Therefore **B** is correct, not **A**.

Question 9 **D**

The process described is annealing the metal, allowing large crystals to form as it cools slowly. This produces metal which is softer, more workable and ductile. **D** is therefore the required answer. Tiny crystals and a hard, brittle metal occur on rapid cooling after heating the metal to red hot. **A** and **B** are incorrect. A hard and flexible metal will not be achieved by cooling a red hot metal slowly. So **C** is not the answer.

Question 10 **A**

Electronegativity increases across the period and up the group. So **B**, a metal, is not the answer. The Group 18 elements show little, if any electronegativity, thus **C** is not the answer. A high first ionisation energy indicates an almost complete outer electron shell, so **A** or **D** is a possible answer. Atomic radius increases down the group, so **D** is an unlikely answer. The Group 17 element with two shells, the outer shell being almost complete, would be expected to have all of the stated characteristics and so **A** is the required answer.

Question 11 **C**

NaCl is soluble in water, so **A** is not the answer. Ni, a metal, conducts electricity when solid, so **B** is not the answer. S, a molecular substance, has a low melting temperature, so **D** is not the answer. CuO is an insoluble ionic compound. Ionic compounds conduct when molten, due to their freely moving ions, but do not conduct when solid as the ions are fixed in the lattice.

Question 12 **D**

The carbon dioxide molecule is linear and non-polar; the ammonia molecule is trigonal pyramidal and polar; and the tetrachloromethane molecule is tetrahedral and non-polar. Thus **A**, **B** and **C** are all incorrect. SF_6 is a non-polar, non-octet molecule with an octahedral structure.

Question 13 **C**

The crucial part of the analysis is to determine the mass of the metal accurately, which will then allow the determination of the mass of oxygen used to form the compound. Step 4 must be done first to ensure this is achieved.

Question 14 **D**

$$n((\text{NH}_4)_3\text{PO}_4) = \frac{m}{M} = \frac{90.0}{149} = 0.604 \text{ mol}$$

$$n(\text{atoms}) = 20 \times n((\text{NH}_4)_3\text{PO}_4)$$

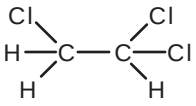
$$N(\text{atoms}) = n \times N_A = 20 \times 0.604 \times 6.02 \times 10^{23} = 7.27 \times 10^{24}$$

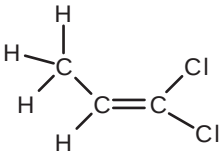
Question 15 B

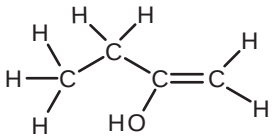
Electrons were discovered earliest using cathode ray tube experiments. Therefore **A** and **D** are incorrect. The work of Rutherford and Aston in the early 1900s showed the presence of the nucleus, and the existence of isotopes. The neutron was confirmed by Chadwick in the 1930s. Therefore **B**, not **C**, is correct. Each discovery allowed the model of atomic structure to be refined.

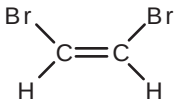
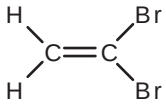
Question 16 A

Addition polymerisation requires the presence of a carbon-carbon double bond. Relevant structures for the molecules listed are shown below. Structure **A** will not polymerise, and so is the required response.

A. 

B. 

C. 

D.  or 

Question 17 A

The polymer chains in type I polyethene can pack closer together than the highly branched type II polymer chains. Thus the dispersion forces between the polymer chains in type I will be stronger than for type II. Stronger dispersion forces would produce a plastic which is stronger, denser, more rigid and melts at a higher temperature than a type II plastic. Thus **B**, **C** and **D** are not correct.

Question 18 C

$$\%N = \frac{m(N)}{m(\text{compound})} = \frac{2 \times 14}{60} \times 100 = 47\%$$

Question 19 B

In the quantum mechanical model of the atom, the shell number is *n*, the number of subshells within a particular shell is *n* and the number of orbitals involved is n^2.

Question 20 D

Surface energy is dependent on the interparticle forces rather than the size of the molecules, and so **A** is incorrect. The strength of the covalent bonds which hold atoms together within a molecule is not relevant. **C** is not correct. As octane is a non-polar molecule, the intermolecular attraction is due to dispersion forces not dipole-dipole bonding. Alternative **B** is incorrect. As water molecules are held to each other by hydrogen bonding, water has a higher surface tension than octane.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $^{40}_{19}K^{+}$

2 marks
1 mark for atomic number and mass number
1 mark for single positive charge

b. Relative isotopic mass compares the mass of an atom of the isotope to the mass of an atom of ^{12}C taken as 12 units exactly. The mass is therefore a ratio and so has no units. 1 mark

c. **i.** The calculation uses a simple mean which does not take account of the differences in abundances of the isotopes. 1 mark

ii. Ar(argon) = $(35.978 \times 0.00307) + (37.974 \times 0.0006) + (39.974 \times 0.99633)$ 1 mark

d. Atomic number is determined by the number of protons in atoms of an element, e.g. K has 19 protons and Ar has 18 protons. 1 mark

As potassium has a large abundance of a lighter isotope (38.975), its RAM is lower than that of argon which has a large abundance of a heavier isotope (39.974). 1 mark

e. Mendeleev used the periodic trends in the properties near these two elements to place them in this particular order 1 mark

Total 8 marks

Question 2

a. Al_2O_3 is an ionic solid consisting of a lattice of aluminium cations and oxide anions. 1 mark

There are very strong electrostatic attractions between these oppositely charged ions. Thus a large amount of energy is required to disrupt this bonding so that the ions can move freely in the liquid state. 1 mark

b. **i.** Both contain mobile charged particles. 1 mark

ii. Al_2O_3 conducts by the movement of ions. Carbon (graphite) conducts by the movement of electrons. 1 mark

c. **i.** Covalent bonds within the molecule. 1 mark

Dispersion forces between the non-polar molecules. 1 mark

ii. The doubly-charged cation in MgO produces a stronger ionic bond than the singly charged cation in Na_2O. 1 mark

The stronger bond means that more energy is needed to disrupt the lattice to form the molten state. 1 mark

d. mass ratio F : Al : Na = 54.3 g : 12.9 g : 32.8 g

mole ratio F : Al : Na $= \frac{54.3}{19.0}$ mol : $\frac{12.9}{27.0}$ mol : $\frac{32.8}{23.0}$ mol

$= 2.86 : 0.478 : 1.43 = 5.98 : 1 : 2.99$ 1 mark

Empirical formula is Na_3AlF_6 1 mark

e. **i.** In the alloy there are different sized ions in the lattice. 1 mark

The presence of these different sized ions makes it difficult for the layers of ions to slide past each other. Thus the alloy is harder. 1 mark

ii. Nanoparticles have a very large surface area compared to their volume. 1 mark

This characteristic increases the strength of interparticle bonding, minimising the spaces between the particles and so producing a much stronger alloy. 1 mark

Total 14 marks

Question 3

a. i. An element's identity is determined by the number of protons in the atoms of the element. 1 mark

As this process changes the number of protons present in the nucleus of a particular atom, it must be a new element. 1 mark

ii. Likely properties can be predicted by reference to other elements in the same group, and by trends in properties of surrounding elements. *(The element's group and period in the Periodic Table is determined using its atomic number.)* 1 mark

iii. f subshell 1 mark

b. i. Helium 1 mark

ii. 3 *(30 + 82 – 106 = 3 × 2)* 1 mark

c. i. $[Ne]3s^2 3p^4$ 1 mark

ii. $[Ar]3d^7$ 1 mark

iii.

$[Rn]5f^{14}6d^7 7s^2$	
$[Xe]4f^8 5d^1 6s^2$	
$[Rn]5f^7 6d^1 7s^2$	✓
$[Rn]6f^1 7s^2$	

1 mark

d. i. decreasing *(due to increasing core charge)* 1 mark

ii. The trend in atomic radius is largely due to the increasing core charge, and thus the increasing 'pull' on the outer shell electrons. 1 mark

Moving across the actinides and transition metals, with each proton added to the nucleus, an electron is added to an inner shell. Thus the core charge, and so the atomic radius, remains relatively constant. 1 mark

Total 12 marks

Question 4

a. i. **D** and **G** 1 mark

ii. **E** or **F** 1 mark

iii. one of **A**, **B**, **C**, or **D** 1 mark

b. **D** 1 mark

C and **F** are non-polar compounds which have weak dispersion forces at their intermolecular bonds. These require only low temperatures for their disruption to cause boiling. 1 mark

D has a hydroxyl group which would allow hydrogen bonding between the molecules. This would require a much higher temperature to disrupt in order to produce boiling. 1 mark

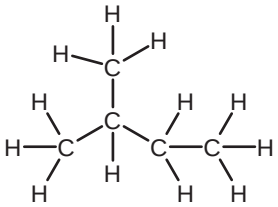
c. **i.** On heating using a catalyst: $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

2 marks
1 mark for reactants and products
1 mark for reference to heat and/or catalyst

ii. $C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(l)$

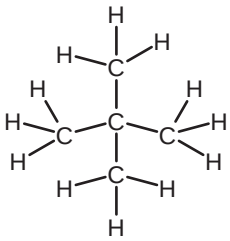
2 marks
1 mark for correct formulas
1 mark for correct states and balancing

d.



2-methylbutane

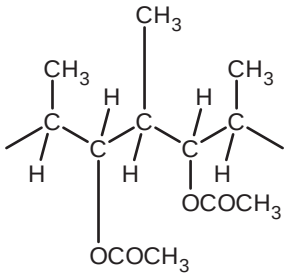
or



2,2-dimethylpropane

2 marks
1 mark for correct structure
1 mark for correct name

e.



2 marks
1 mark for chain structure with single bonds between carbon atoms
1 mark for $-CH_3$ and $-OCOCH_3$ groups bonded to alternating carbon atoms

f. M(compound **H**) = 100.0 g mol^{-1} 1 mark

$$\text{mass of one molecule} = \frac{100.0}{(6.02 \times 10^{23})} = 1.66 \times 10^{-22} \text{ g}$$

1 mark

Total 16 marks