Solutions

Practice Exam 1

Section A – Multiple-choice questions

Question 1 **A**

Number the carbons from the right-hand end. Methyl groups (CH_3) are attached to carbons 2 and 4. The longest continuous carbon chain has 5 carbons, hence it is pentane. Octane is not the systematic name – the molecule shown is an isomer of octane.

Question 2 **A**

Electron shells were not proposed until the early 1900s. Mendeleev did not therefore relate properties to electron shell configuration. Therefore, **A** is incorrect. Statements **B**, **C** and **D** are correct.

Question 3 **C**

Hydrogen bonding occurs between molecules which contain hydrogen bonded to F, O or N. The molecule in **C** is the only one which fits this criterion.

Question 4 **B**

Protons and alpha particles ($^4_2He^{2+}$) will be deflected toward the negative electrode. Therefore **C** and **D** are incorrect. Protons will be deflected more than alpha particles because they are lighter. Therefore, **B** is correct.

Question 5 **A**

Polymer **A** will have hydrogen bonding between polymer chains. Polymers **B**, **C** and **D** will have dispersion forces only. Hydrogen bonds are stronger, leading to a higher boiling point. The branching in polymer **D** would lead to a lower boiling point.

Question 6 **D**

Elements in the same group have the same outer-shell configuration, leading to similar chemical properties. Elements in a group do not have the same electronic configuration or atomic number or atomic mass.

Question 7 **B**

Metal have low electronegativity, hence sodium is first. Electronegativity decreases down a group, so bromine before chlorine.

Question 8 **D**

H_2S is a V-shaped molecule like water. There are four electron pairs around the S, two bonding and two non-bonding.

Question 9 **A**

MgO and $CaCl_2$ are ionic. Solid $CaCl_2$ has fixed ions and therefore does not conduct. S is molecular and does not conduct in either solid or molten states. Zn is a metal which conducts by movement of electrons.

Question 10 **D**

W and X both represent 2-methylbutane.

Question 11 **C**

6.02×10^{23} atoms of an element (1 mole) have a mass equal to the molar mass of the element. If 1 atom has a mass of 4.49×10^{-23} g then 6.02×10^{23} atoms have a mass of $4.49 \times 10^{-23} \times 6.02 \times 10^{23}$ g.

Therefore the molar mass is 27 g mol^{-1}. The RAM is 27. The element is therefore Al.

Question 12 **A**

A. 1 mole of O_2 = 2 mole of O atoms = 12×10^{23} atoms

B. 6×10^{23} atoms

C. 24 g of $O_2 = \frac{24}{32} = 0.75$ mole of O_2

$= 0.75 \times 2$ mole of O atoms $= 9 \times 10^{23}$ atoms

D. 24 g of $O_3 = \frac{24}{48} = 0.5$ mole of O_3

$= 0.5 \times 3$ mole of O atoms $= 9 \times 10^{23}$ atoms

$\therefore$ The largest number of atoms is 12×10^{23}.

Question 13 **D**

$$n_1(Na^+) = n(NaCl) = n(Cl^-) = 0.4 \text{ mol}$$

$$n_2(Na^+) = 2 \times n(Na_2SO_4) = 2 \times n(SO_4^{2-})$$

$$= 2 \times 0.3 = 0.6 \text{ mol}$$

$$\therefore n(Na^+)_{TOTAL} = n_1 + n_2 = 0.4 + 0.6 = 1.0 \text{ mol}$$

Question 14 **D**

The energy of subshells in any one shell is s < p < d. Therefore, **A** is a correct statement.

There are five orbitals in a d subshell. Therefore, **B** is correct.

Pauli's exclusion principle states that a maximum of two electrons per orbital applies to d subshells. Therefore, **C** is correct.

The 3d subshell fills after the 4s subshell. Therefore **D** is incorrect and so is the required response.

Question 15 **C**

A has too many hydrogen atoms. **B** has a hydrogen atom with two bonds, which is impossible. **D** has a carbon atom with five bonds, which is impossible. Hence **C** is the correct answer.

Question 16 **B**

Atomic radii decrease across a period, i.e. the radius of Mg is less than the radius of Na. Therefore, **A** is incorrect.
Electrons from both Na and Mg come from the s subshell. Therefore, **C** is incorrect.
The number of isotopes does not influence the ease with which an electron may be removed from an atom. Therefore, **D** is incorrect.
The greater nuclear charge in Mg (12 compared with 11 in Na) means that the outer-shell electron is held more tightly and hence is more difficult to remove.

Question 17 **B**

Thomson's gas discharge tube experiments revealed electrons and were carried out in the late 1800s. Protons were discovered in the early 1900s (although the existence of positive particles was suggested earlier). Chadwick confirmed the existence of neutrons in the 1930s.

Question 18 **C**

Ethene is more reactive than ethane, due to the presence of the reactive double bond. **C** is therefore an incorrect statement.
The statements in **A**, **B** and **D** are correct.

Question 19 **B**

Pentane: There are weak dispersion forces between molecules, so there is low surface tension.
Ethanol: There are some hydrogen bonds between molecules, so there is medium surface tension.
Water: There are hydrogen bonds between molecules, so there is high surface tension.
Mercury: There are metallic bonds between particles, so there is very high surface tension.

Question 20 **C**

Wax is a non-polar substance held together by dispersion forces.
Iron is metallic.
Diamond is a covalent network lattice.

Section B – Short-answer questions

Question 1

a.

Ion	Mass number	Atomic number	Number of neutrons	Number of electrons	Valency of ion
A	56	**26**	30	**24**	+2
B	**35**	17	18	18	**–1**

b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

c. **i.** An atom is said to be in its 'ground state' when its electrons are in the lowest possible energy state.

ii. $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$
(or any other configuration in which electrons have been promoted from their 'ground state')

d. AB_2 ($FeCl_2$)

Question 2

a. **i.** Chemical properties are determined by electron configuration. Isotopes have the same number of electrons, hence the same electron configuration.

ii. $\text{RAM} = \sum(\text{RIM} \times \text{abundance fraction})$

$$= \left(85 \times \frac{75}{100}\right) + \left(87 \times \frac{25}{100}\right)$$

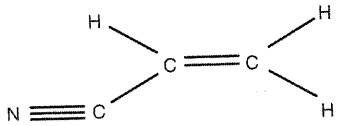
$$= 85.5$$

b. **i.** The number of electron shells increases down a group.

ii. In the negative ion, there is increased repulsion between added electrons in the outer shell of the ion.

Question 3

a. **i.**



ii. Addition

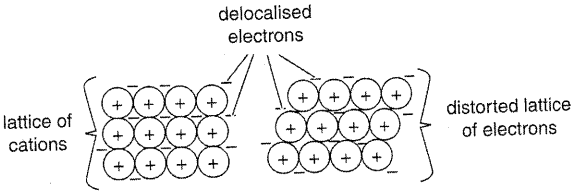
iii. Dipole–dipole (not hydrogen bonding since H is not covalently bonded to F, O or N).

b. **i.** C_3H_3N

ii. $N = \dfrac{5.04 \times 10^4}{53} = 951$

Question 4

a. Metals consist of a lattice of cations immersed in a sea of electrons. Strong electrostatic forces bind the cations and electrons together. When cations are moved, the flow of electrons allows a change of shape without disrupting the electrostatic forces, hence metals are malleable.



b. **i.** For example:
- high melting point
- ductile
- electrical conductor

ii. Liquid expands when heated.

c. **i.** A mixture of metals, or a metal/non-metal mix, which shows metallic properties.

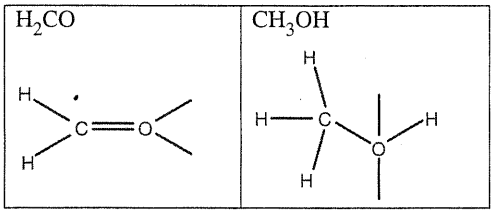
ii. For example:
- Alloys are less corrosive.
- Alloys are less malleable.
- Alloys are harder.
- Alloys may have lower melting points.

Question 5

a.

Name of substance	Formula of substance	Structural type
copper(II) hydroxide	$Cu(OH)_2$	Ionic lattice
ammonia	NH_3	Molecular
diamond	C	Covalent network lattice

b. **i.**



ii. Both are polar molecules and hence both have dipole–dipole intermolecular bonds. Methanol has hydrogen bonding between molecules. As this is stronger than dipole–dipole bonding, methanol's boiling point is much higher. Both substances have similar dispersion forces between molecules (due to similar molecular masses).

Question 6

a.

$$NH_4Cl\ \%N = \frac{M(N)}{M(NH_4Cl)} \times \frac{100}{1} = \frac{14.0}{53.5} \times \frac{100}{1}$$
$$= 26.2\%$$
$$NaNO_3\ \%N = \frac{M(N)}{M(NaNO_3)} \times \frac{100}{1} = \frac{14.0}{85.0} \times \frac{100}{1}$$
$$= 16.5\%$$

b. **i.**

N	:	H	:	O	
$\frac{35.0}{14.0}$	:	$\frac{5.00}{1.00}$	:	$\frac{60.0}{16.0}$	
2.5	:	5.0	:	3.75	
1	:	2	:	1.5	
2	:	4	:	3	$N_2H_4O_3$

ii. NH_4NO_3

Question 7

a. Linear polymers (A) produce plastics which are soft and melt when heated. These include polypropene and nylon.

Cross-linked polymers (B) produce plastics which are hard and do not soften when heated. Such plastics are used for frying-pan handles, and include phenol-methanal.

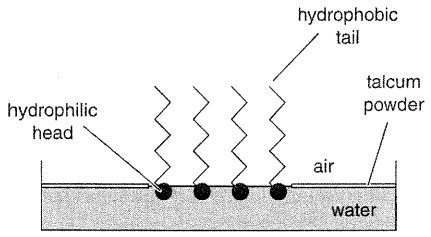
b. **i.** Thermosetting

ii. Take a very small piece of polymer in a pair of tongs and heat using a Bunsen burner in the fume cupboard. A thermoplastic polymer will melt or burn. A thermosetting polymer will not melt, it will char.

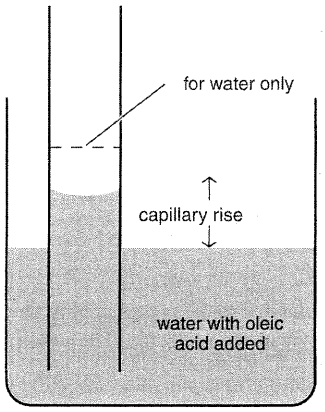
Question 8

a. Oleic acid has a hydrophobic (non-polar, water fearing) 'tail' ($C_{17}H_{33}$) and a hydrophilic (polar) 'head' (–COOH) which binds to polar water molecules.

b. The 'tails' point outwards from the water surface. The 'heads' point inwards.



c. **i.**



ii. The addition of the oleic acid reduces the surface tension of the water. With lower surface tension the 'pull' due to surface tension decreases, hence capillary rise decreases.