SECTION A – Multiple-choice questions

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No mark will be given if more than one answer is completed for any question.

Question 1

Four important scientific discoveries in the development of atomic theory are listed in alphabetical order: electron, neutron, nucleus, proton.

Which of the following gives the correct chronological order of discovery?

A. proton, nucleus, electron, neutron
B. nucleus, proton, electron, neutron
C. electron, proton, neutron, nucleus
D. electron, nucleus, proton, neutron

neutron last
electron 1st

Question 2

Which one of the following is **not** conserved in a chemical reaction?

A. the number of mole of substances
B. the mass
C. the number of atoms
D. the number of nuclei

} none of these change

Question 3

The periodic table is compiled by arranging elements in increasing order of

A. electronegativity
B. mass number
C. relative atomic mass
D. atomic number

(number of protons)

Question 4

The **ground-state** electronic configuration for a phosphide ion, P^{3-}, is

A. $1s^2,2s^2,2p^6,3s^2,3p^4,4s^2$.
B. $1s^2,2s^2,2p^6,3s^2,3p^3$.
C. $1s^2,2s^2,2p^6,3s^2$.
D. $1s^2,2s^2,2p^6,3s^2,3p^6$.

P atom (15)
$1s^2 2s^2 2p^6 3s^2 3p^3$
P^{3-} gains $3e^-$ ∴ $1s^2 2s^2 2p^6 3s^2 3p^6$

Question 5 Halogens

When going down Group 17, which one of the following occurs?

A. the elements become more reactive (less for non-metals)
B. the first ionisation energy decreases
C. the atomic radius decreases (↓ a group gets bigger)
D. the attraction between the nucleus and valence electron increases (decreases).

Question 6

An atom of an element has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$. (21) Sc

Which one of the following statements would describe the properties of this element?

A. Does not conduct electricity as a solid, is reasonably reactive and has a low electronegativity.
B. Conducts electricity as a solid, is reasonably reactive and has a high electronegativity.
C. Does not conduct electricity as a solid, is unreactive and has a low electronegativity.
D. Conducts electricity as a solid, is reasonably reactive and has a low electronegativity.

Transition Metal
properties of a metal.

metals have low electroneg.

Question 7

O^{2-}

In an excited state, the electrons of an oxide **ion** could occupy at least

A. 1 subshell
B. 2 subshells
C. 3 subshells
D. 4 subshells

O atom $1s^2 2s^2 2p^4$
O^{2-} ion $1s^2 2s^2 2p^6$

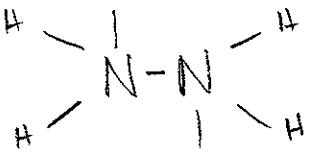
subshell not shell

excited ion
valence electron promoted to higher level eg $1s^2 2s^2 2p^5 3s^1$

Question 8

How many lone pairs **in total** do the nitrogen atoms have in their valence shells in the molecule, N_2H_4?

A. 0
B. 1
C. 2
D. 3



Question 9

The difference between the relative molecular mass of carbon dioxide and the molar mass of carbon dioxide is that the relative molecular mass and the molar mass of carbon dioxide are respectively:

A. 44.0 g and 1 mol
B. 44.0 and 44.0 g mol^{-1}
C. 44.0 g and 44.0 g mol^{-1}
D. 44.0 and 44.0 g

Question 10

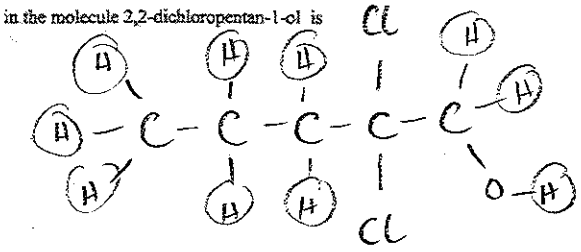
The number of significant figures in the answer for the calculation $8.0260 \times 10^{-2} + 14$ will be

A. two
B. three
C. four
D. five

Question 11

The number of H atoms in the molecule 2,2-dichloropentan-1-ol is

A. 7
B. 8
C. 9
D. 10



Questions 12 and 13 refer to the following table of information.

Substance	Melting Point (°C)	Boiling Point (°C)	Electrical conduction of substance		
			In solid state	Molten liquid	As solution in water
A	−25	144	Poor	Poor	Insoluble
B	−51	−35	Poor	Poor	Good
C	1453	2835	Good	Good	Insoluble
D	712	1412	Poor	Good	Good

Question 12

Which of the substances A, B, C or D is a gas at room temperature?

A. Substance A
B. Substance B
C. Substance C
D. Substance D

Question 13

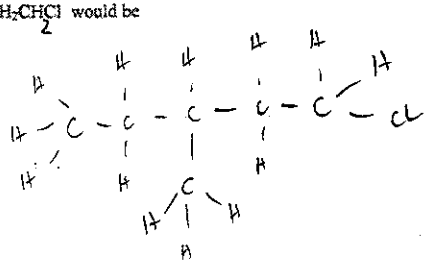
Which of the substances A, B, C or D has a structure made up of cations and anions?

A. Substance A
B. Substance B
C. Substance C
D. Substance D

Question 14

The correct IUPAC name of $CH_3CH_2CH(CH_3)CH_2CHClCH_3$ would be

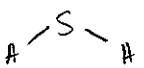
A. 1-chloro-3-methylpentane
B. 3-methyl-6-pentachloride
C. 1-chloro-2-methylpentane
D. 1-chloro-4-ethylbutane

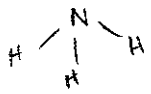


Question 15

Which of the following molecules would be most polar?

A. CO_2 O=C=O non
B. H_2S
C. H_2 H—H non
D. NH_3





N more electronegative than S so D

Question 16

Which one of the following contains both covalent and ionic bonds?

A. CH_3OH — covalent
B. Na_2CO_3 — Na^+ CO_3^{2-}
C. Al_2O_3 — ionic
D. NaCl — ionic

This is a covalent compound

Question 17

Astatine, At, is a radioactive halogen. What would the formula for both gaseous astatine molecules and the sodium salt of astatine most likely be?

A. At_2 and $NaAt_2$
B. At_3 and NaAt
C. At_2 and Na_2At
D. At_2 and NaAt

Na^+ At^- = NaAt

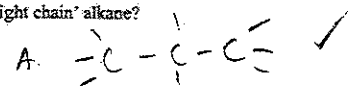
At_2

Question 18

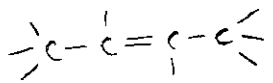
Which of the following could not be a 'straight chain' alkane?

A. C_3H_8
B. C_4H_8
C. $CH_3CH_2CH_2CH_2CH_3$
D. C_6H_{14}

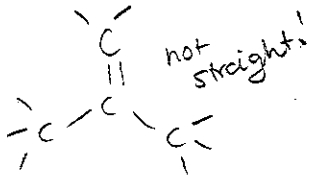
A.



B.



or



not straight!

Question 19

Arrange the following covalent bonds in increasing order of polar character (least polar first)

C-C	Na-O	C-N	O-H	C-O
I	II	III	IV	V
2.5 2.5 = 0	0.9 3.5 = 1.6	2.5 3 = .5	3.5 2.1 = 1.4	2.5 3.5 = 1

A. III, I, IV, II, V
B. V, III, I, II, IV
C. I, III, V, IV, II
D. I, III, II, IV, V

I, III, V, IV, II

Question 20 $MgCl_2$ N

The mass, in g, of magnesium chloride that contains 9.00×10^{23} chloride ions would be closest to

A. 44.8
B. 71.3
C. 95.3
D. 141

$N(Cl^-) = 9.00 \times 10^{23}$

$N(MgCl_2) = \frac{9.00 \times 10^{23}}{2}$

$= 4.5 \times 10^{23}$

$n(MgCl_2) = N/N_A$

$= \frac{4.5 \times 10^{23}}{6.02 \times 10^{23}}$

$= 0.748$ mol

$m(MgCl_2) = n \times M$ ($M(MgCl_2)$ = 95.3)

$= 0.748 \times 95.3$

$= 71.3$ g.

END OF SECTION A

SECTION B – Short answer questions

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

Question 1

The idea of the core charge of an atom can be useful in explaining trends in properties of elements in Period 3 of the Periodic Table. The core charge is determined by considering the effective nuclear charge felt by an outer-shell electron in the atom. Thus sodium, with 11 protons and 10 inner-shell electrons, has a core charge of +1.

a. i. Write the electronic configuration, using subshell notation, for an aluminium atom in an excited state.

$1s^2 2s^2 2p^6 3s^2 4s^1$ (for example) /13

ii. Explain why aluminium is placed in Period 3 of the Periodic Table.

Because in its ground state it has electrons in 3 shells.

iii. What is the core charge of an aluminium atom?

Al 13p+ 10 inner electrons = +3

1 + 1 + 1 = 3 marks

b. Explain why the radius of an aluminium atom is larger than the radius of

i. an atom of phosphorus.

Both have electrons in 3 shells, but P has a greater core charge, drawing shells in closer

ii. an aluminium ion.

Al loses $3e^-$, ∴ only having e^- in 2 shells which is smaller than 3 shells.

2 + 2 = 4 marks

Question 2

a. Calculate the empirical formula for a hydrocarbon which contains 92.3 % carbon.

C H

92.3 | 7.7 EF = CH

÷R 7.69 | 7.7 ÷1

1 | 1 ÷smallest

3 marks

b. If the molar mass of the hydrocarbon is 78.0 g mol^{-1}, determine the molecular formula.

M(CH) = 13 g/mol 78/13 = 6

∴ C_6H_6

2 marks

Total 5 marks

Question 3

a. Write the formula for copper (II) chloride: $CuCl_2$ (Cu^{2+} Cl^-)

1 mark

b. Calculate the amount of substance, in mol, in 8.02 g of copper (II) chloride.

n m

$n(CuCl_2) = 8.02/134.6$

$= 0.0596$ mol.

2 marks

c. Determine the amount of chloride ions, in mol, in 8.02 g of copper (II) chloride.

n m

$n(Cl^-) = 2 \times n(CuCl_2) = 0.0596 \times 2 = 0.119$ mol

2 marks

d. Determine the number of chloride ions in 8.02 g of copper (II) chloride.

$N(Cl^-) = n \times N_A = 0.119 \times 6.02 \times 10^{23}$

$= 7.17 \times 10^{22}$

1 mark

Total 6 marks

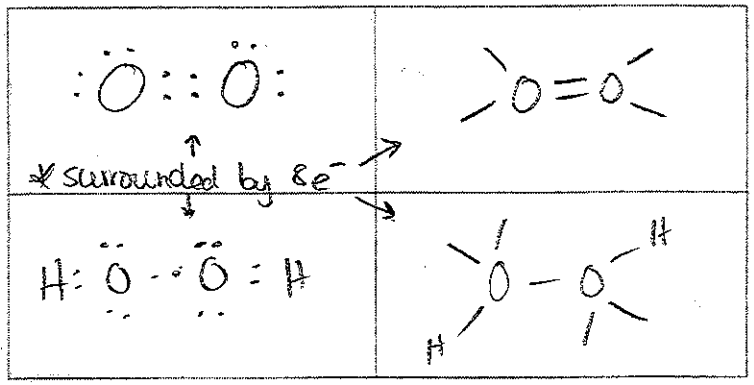
Question 4

O_2

Evidence shows that the distance between two oxygen atoms in molecular oxygen is less than the bond between two oxygen atoms in hydrogen peroxide (H_2O_2).

a. Draw an electron dot diagram (Lewis diagram) and the structural formula for both molecular oxygen and hydrogen peroxide.

H makes 1, O makes 2.



4 marks

b. Explain why the distance between the oxygen atoms is less in molecular oxygen than in hydrogen peroxide.

In O_2, the double bond means that there are 4 electrons between the 2 O atoms. Therefore there is a greater attraction than in a single O–O bond.

2 marks

c. Explain why oxygen cannot normally form three covalent bonds.

O has 6 valence e⁻. It needs 2 to have a full outer shell.

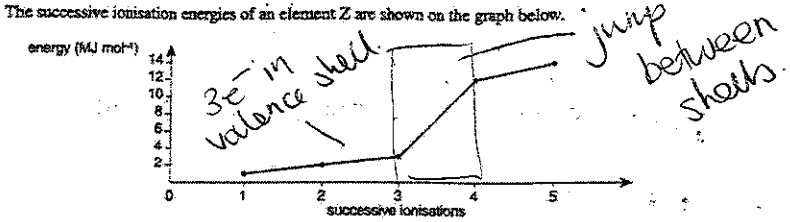
∴ It makes 2 covalent bonds.

2 marks

Total 8 marks

Question 5

The successive ionisation energies of an element Z are shown on the graph below.



i. Write an equation which describes the first ionisation of Z.

$Z \rightarrow Z^+ + e^-$

ionisation energy → energy it takes to remove an outer electron

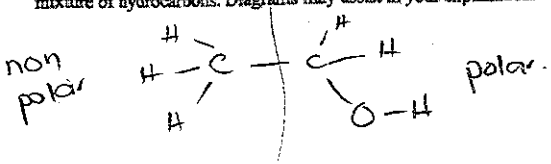
ii. Use the graph to predict the valency of the most likely cation formed by Z.

Z^{3+}

1 + 1 = 2 marks

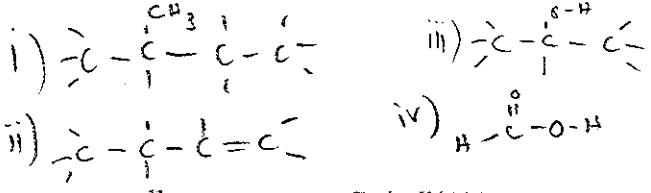
Question 6

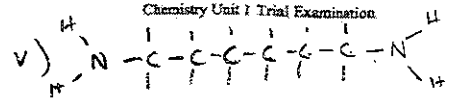
Explain in terms of bonding why ethanol can dissolve in water and petrol which is mostly a mixture of hydrocarbons. Diagrams may assist in your explanation.



Ethanol has a polar end (able to H bond with H_2O) that can dissolve in water and a non-polar end, which can bond (and dissolve) in non-polar hydrocarbons. (petrol, diesel fuel).

Total 4 marks





Question 7

a. Write the correct IUPAC name of the following organic substances.

i. $CH_3CH(CH_3)CH_2CH_3$ 2-methyl butane

ii. $CH_3CH_2CHCH_2$ but-1-ene

iii. $CH_3CH(OH)CH_3$ 2-propanol

iv. $HCOOH$ methanoic acid.

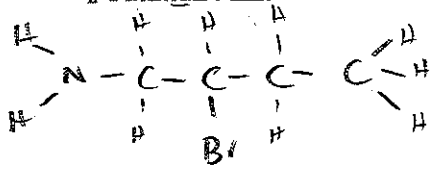
v. $H_2NCH_2(CH_2)_4CH_2NH_2$ diamino hexane.

TOO tricky!

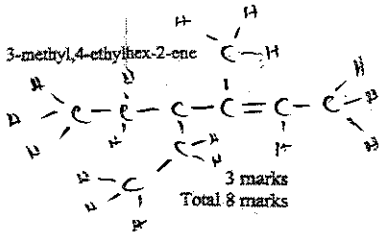
5 marks

b. Draw the structure, showing all bonds, of

i. 2-bromobutan-1-amine



ii. 3-methyl,4-ethylhex-2-ene

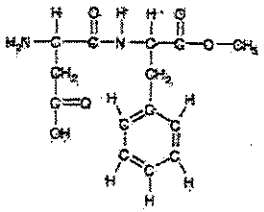


3 marks

Total 8 marks

Question 8

Aspartame is an artificial sweetener used in soft drinks. The structure of aspartame is shown below.



a. i. What is the molecular formula of aspartame?

$C_{14}H_{18}O_5N_2$

ii. What is the percentage by mass of nitrogen in aspartame?

$M(C_{14}H_{18}O_4N_2) = 14\times12 + 18\times1 + 5\times16 + 2\times14$

$= 168 + 18 + 80 + 28$

$= 294$

$M(N) = 2\times14$

$= 28$

$\%\ mass = \frac{N}{Total} \times 100$

$= \frac{28}{294} \times 100$

$= 9.52\%$

$\div 1000 \rightarrow g$

b. One sugar-substitute tablet contains 250 mg of aspartame.

i. Calculate the amount (in mol) of aspartame in one tablet.

$250mg = 0.25g.$ $n(aspartame) = \frac{M}{M}$

$= 0.25/294$

$= 8.5\times10^{-4}$ mol.

ii. Calculate the mass of carbon that could be obtained from one tablet of aspartame.

$n(C) = 14 \times n(aspartame)$

$= 14 \times 8.5\times10^{-4}$

$= 1.19\times10^{-2}$ mol

$m(C) = n \times M$

$= 1.19\times10^{-2} \times 12$

$= 0.143g.$

1 + 1 = 2 marks

Total 4 marks

forms.

Question 9

Diamond and graphite are both common allotropes of carbon. They share the same C atoms as building blocks but have very different abilities to conduct electricity.

Describe both the structure and bonding in diamond and graphite and use this to explain their ability to conduct electricity.

Graphite is able to conduct electricity as it is a covalent layer lattice. Each C only makes 3 covalent bond, leaving 1 electron to become delocalised. This delocalised electron is a free charged particle, allowing electricity to flow.

In diamond (a covalent network lattice) each C is covalently bonded to 4 other C's. There are no mobile charged parcels, therefore no electricity can travel through

Total 8 marks

END OF EXAMINATION