INSIGHT

Trial Exam Paper

YEAR 11 CHEMISTRY

Written examination 1

Solutions book

This book presents:

- correct solutions with full working
- explanatory notes
- mark allocations
- tips and guidelines

SECTION A – Multiple-choice questions

Question 1

An ion that contains 8 protons, 9 neutrons and 10 electrons will have a mass number and charge corresponding to

	Mass number	Charge
A.	9	–2
B.	9	+2
C.	**17**	**–2**
D.	17	+2

Answer is C.

Explanatory notes

- C is correct. The mass number of an atom or ion gives the number of neutrons plus the number of protons in the nucleus. In this case, 9 neutrons + 8 protons = 17. The charge on the ion reflects the number of electrons, which have a charge of –1, compared to the number of protons, which have a charge of +1. In this case, there are two more electrons than protons so the charge on the ion is –2.
- A is incorrect because the mass number of this ion is 17.
- B is incorrect because the mass number of this ion is 17 and the charge is –2.
- D is incorrect because the charge on this ion is –2.

Question 2

The ground state electronic configuration for $_{16}S^{2-}$ is

A. $1s^2 2s^2 2p^6 3s^2 3p^4 4s^2$

B. $1s^2 2s^2 2p^6 3s^2 3p^2$

C. $1s^2 2s^2 2p^6 3s^2 3p^4$

D. $\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6}$

Answer is D.

Explanatory notes

- D is correct. $_{16}S^{2-}$ has an atomic number of 16 so contains 16 protons. In a neutral S atom there would also be 16 electrons. However, this ion carries a –2 charge, so has two additional electrons, making a total of 16 + 2 = 18 electrons.
- A is incorrect because the 18 electrons shown are not shown in the ground state configuration. The 3p subshell will fill with 6 electrons before the 4s subshell begins to be filled.
- B is incorrect because only 14 electrons are shown, not the correct 18.
- C is incorrect because only 16 electrons are shown, not the correct 18.

Question 3

The characteristic that is used as a basis for placing elements into **periods** on the Periodic Table is

A. atomic number

B. mass number

C. number of electrons in the outer shell

D. **number of occupied electron shells**

Answer is D.

Explanatory notes

- D is correct. Elements in the same period have the same number of occupied electron shells. Each period represents the filling of a new electron shell.
- A is incorrect because although elements are placed in the Periodic Table in order of increasing atomic number, they are not classified into periods on this basis.
- B is incorrect because the mass number of elements is not used to place elements in the Periodic Table.
- C is incorrect because the number of electrons in the outer shell is used to place elements into the same group, not the same period.

Question 4

The 3d subshell has

A. 3 orbitals and can hold up to 6 electrons

B. **5 orbitals and can hold up to 10 electrons**

C. 3 orbitals and can hold up to 9 electrons

D. 5 orbitals and can hold up to 15 electrons

Answer is B.

Explanatory notes

- B is correct because regardless of the shell number, all d subshells have 5 orbitals and all orbitals can contain a maximum of 2 electrons each, making a total of 10 electrons.
- A is incorrect because all d subshells have 5 orbitals.
- C is incorrect because all d subshells have 5 orbitals.
- D is incorrect because all orbitals can contain a maximum of 2 electrons each.

Question 5

The element that is chemically most similar to the element with atomic number 17 is

A. S

B. Ar

C. **Br**

D. P

Answer is C.

Explanatory notes

- C is correct because Br is in the same group on the Periodic Table as the element with atomic number 17 and so has the same number of electrons in its outer shell. Hence, it shares similar chemical properties.
- A is incorrect because although S is the element before the element with atomic number 17 and they are in the same period, they are not in the same group. It is the elements in the same group that have similar chemical properties.
- B is incorrect because although Ar is the element after the element with atomic number 17 and they are in the same period, they are not in the same group. It is the elements in the same group that have similar chemical properties.
- D is incorrect because although P is the element two places before the element with atomic number 17 and they are in the same period, they are not in the same group. It is the elements in the same group that have similar chemical properties.

Question 6

The total number of atoms in 5.00 g of propane (C_3H_8) is

A. 0.114

B. 6.84×10^{22}

C. 1.25

D. $\mathbf{7.53 \times 10^{23}}$

Answer is D.

Explanatory notes

- D is correct according to the calculations below.

  Step 1: Determine the amount, in mol, of propane.

  $$n(C_3H_8) = \frac{m}{M}$$
  $$= \frac{5.00}{(3\times12.0+8\times1.0)}$$
  $$= \frac{5.00}{44.0}$$
  $$= 0.114 \text{ mol}$$

  Step 2: Determine the amount, in mol, of atoms present.

  n(atoms) = $n(C_3H_8)$ × number of atoms in one molecule of C_3H_8

  = 0.114 × (3 carbon atoms + 8 hydrogen atoms)
  = 0.114 × 11
  = 1.25 mol

  Step 3: Determine the total number of atoms.

  N(atoms) = $n \times N_A$

  $= 1.25 \times 6.02 \times 10^{23}$
  $= 7.53 \times 10^{23}$

- A is incorrect because 0.l14 is the amount, in mol, of propane present, not the total number of atoms.
- B is incorrect because 6.84×10^{22} is the number of propane molecules, not the total number of atoms. A single propane molecule contains 3 carbon atoms + 8 hydrogen atoms = 11 atoms in total, so the number of atoms = $6.84 \times 10^{22} \times 11$.
- C is incorrect because 1.25 is the amount, in mol, of atoms present, not the total number of atoms. One mole of atoms contains Avogadro's number of atoms, so the total number of atoms here = $1.25 \times 6.02 \times 10^{23}$.

Question 7

Ammonium sulfate, $(NH_4)_2SO_4$, is often used as a source of soluble nitrogen for plants. The mass of nitrogen in 300 kg of ammonium sulfate, in kilograms, is

A. 10.6

B. 21.2

C. 38.8

D. **63.6**

Answer is D.

Explanatory notes

- D is correct according to the calculations below.

  Step 1: Determine the percentage, by mass, of nitrogen in ammonium sulfate.

  $$\% \text{ by mass} = \frac{\text{Mass of the element in 1 mol of the compound}}{\text{Molar mass of the compound}} \times 100$$

  $$\% \text{ N} = \frac{2 \times 14.0}{(2 \times (14.0 + 4 \times 1.0) + 32.1 + 4 \times 16.0)} \times 100$$

  $$= \frac{28.0}{136.1} \times 100$$
  $$= 21.2\%$$

  Step 2: Determine the mass of nitrogen in 300 kg of ammonium sulfate.

  m(N) = 21.2 % of 300 kg

  $$= \frac{21.2}{100} \times 300$$
  $$= 63.6 \text{ kg}$$

- A is incorrect because there are two N atoms in the formula of ammonium sulfate, so the percentage by mass is 29.1%. The mass of nitrogen in 300 kg of ammonium sulfate also needs to be determined.
- B is incorrect because 29.1 is the percentage by mass of nitrogen in ammonium sulfate, not the actual mass of nitrogen in 300 kg of ammonium sulfate.
- C is incorrect because there are two N atoms in the formula of ammonium sulfate, so the percentage by mass is 29.1%.

  An alternative method for calculating the mass of nitrogen in 300 kg of ammonium sulfate is shown below.

  $$n((NH_4)_2SO_4) = \frac{\text{Mass in grams of compound}}{\text{Molar mass of compound}}$$

  $$= \frac{300 \times 1000}{132.1}$$
  $$= 2271 \text{ g}$$

  n(N atoms) : $n((NH_4)_2SO_4)$ = 2 : 1
  = 4542 mol

  m(N atoms) = 4542 × 14 g mol^{-1}
  = 63 588 g = 63.6 kg

Question 8

The mass of one molecule of water (H_2O), in grams, is

A. $\dfrac{\mathbf{18.0}}{\mathbf{6.02 \times 10^{23}}}$

B. 18.0

C. $\dfrac{6.02 \times 10^{23}}{18.0}$

D. $6.02 \times 10^{23} \times 18.0$

Answer is A.

Explanatory notes

- A is correct. The molar mass of water is 18.0 g mol^{-1}, which means that one mole of water containing 6.02×10^{23} water molecules has a mass of 18.0 g. The molar mass needs to be divided by 6.02×10^{23} to determine the mass of a single molecule.
- B is incorrect because 18.0 is the molar mass of water in g mol^{-1}, so represents the mass of 6.02×10^{23} molecules, not just one.
- C is incorrect because the molar mass of water needs to be divided by 6.02×10^{23} to determine the mass of a single water molecule.
- D is incorrect because the molar mass of water needs to be divided by 6.02×10^{23} to determine the mass of a single water molecule.

Tip

- *Common sense can be useful when completing multiple-choice questions. The mass of one molecule of any substance must be extremely small, so options B, C and D should be readily discarded.*

Question 9

16.0 g of nitrogen is converted completely into an oxide of nitrogen. The mass of the oxide formed is 52.6 g.

The empirical formula of the oxide would be

A. NO

B. $\mathbf{NO_2}$

C. NO_3

D. N_2O_5

Answer is B.

Explanatory notes

- B is correct according to the calculations below.

  Step 1: Determine the mass of each element present.

  $m(N_2) = 16.0$ g

  $m(O_2) = 52.6 - 16.0 = 36.6$

  Step 2: Calculate the amount, in mol, of each element present to determine a mole ratio.

  $n(N_2) = \frac{m}{M} = \frac{16.0}{28.0} = 0.571$ mol

  $n(O_2) = \frac{m}{M} = \frac{36.6}{32.0} = 1.14$ mol

  Step 3: Divide each amount, in mol, by the smallest number to simplify the ratio.

  $\frac{0.571}{0.571} = 1$

  $\frac{1.14}{0.571} = 2$

  Step 4: Write the empirical formula.

  NO_2

- A is incorrect because the ratio of nitrogen to oxygen atoms is 1 : 2, not 1 : 1.
- C incorrect because the ratio of nitrogen to oxygen atoms is 1 : 2, not 1 : 3.
- D is incorrect because the ratio of nitrogen to oxygen atoms is 1 : 2, not 2 : 5.

Question 10

Which of the following lists contains only empirical formulas?

A. HCl, C_2H_6, CO_2, $NaNO_3$

B. $AlCl_3$, CH_4, CO, $C_6H_{12}O_6$

C. CH_3COOH, $NaCl$, $MgNO_3$, H_2O

D. **MgC_{12}, C_3H_8, SO_3, Cu_2O**

Answer is D.

Explanatory notes

- D is correct because the empirical formula is the simplest whole number ratio of atoms in a compound. None of these formulas can be simplified any further.
- A is incorrect because C_2H_6 can be simplified to the ratio CH_3.
- B is incorrect because $C_6H_{12}O_6$ can be simplified to the ratio CH_2O.
- C is incorrect because CH_3COOH can be simplified to CH_2O.

Question 11

Which of the following substances **does not** contain charged particles arranged in a lattice structure when in solid form?

A. **diamond**

B. potassium chloride

C. iron

D. sodium nitrate

Answer is A.

Explanatory notes

- A is correct because diamond is a covalent network lattice of carbon atoms. Each carbon atom forms strong covalent bonds with four other carbon atoms based on the sharing of electrons. The carbon atoms are not charged particles.
- B is incorrect because solid potassium chloride forms an ionic lattice containing positive cations and negative anions.
- C is incorrect because iron is a metal and its lattice structure contains cations and negatively charged delocalised electrons.
- B is incorrect because solid sodium nitrate forms an ionic lattice containing positive cations and negative anions.

Question 12

The correct formula of aluminium oxide is

A. AlO

B. AlO_3

C. **Al_2O_3**

D. Al_3O_2

Answer is C.

Explanatory notes

- C is correct. Aluminium has 3 electrons in its outer shell. It loses these 3 electrons to form an ion with an electrovalency of +3. Oxygen has 6 electrons in its outer shell. It gains 2 electrons to form an ion with an electrovalency of –2. The overall charge in an ionic compound must be balanced and equal to zero, which in this case requires two Al^{3+} ions and three O^{2-} ions.
- A is incorrect because the Al ion is +3 and the O ion is –2 and the overall charge in the compound must be balanced. AlO would have a charge of +1, so is not balanced.
- B is incorrect because the Al ion is +3 and the O ion is –2 and the overall charge in the compound must be balanced. AlO_3 would have a charge of –3, so is not balanced.
- D is incorrect because the Al ion is +3 and the O ion is –2 and the overall charge in the compound must be balanced. Al_3O_2 would have a charge of +5, so is not balanced.

Question 13

Which of the following models of bonding contains both cations and anions?

A. metallic lattices

B. **ionic lattices**

C. covalent molecules

D. covalent layer lattices

Answer is B.

Explanatory notes

- B is correct because an ionic lattice consists of a regular arrangement of metal cations and non-metal anions.
- A is incorrect because a metallic lattice consists of a regular arrangement of metal cations surrounded by a sea of delocalised electrons. There are no anions present.
- C is incorrect because covalent molecules are formed when non-metal atoms share outer shell electrons. There are no cations or anions present.
- D is incorrect because a covalent layer lattice forms when covalent bonds extend throughout layers in a substance with weak dispersion forces between layers. There are no cations or anions present.

Question 14

Atom X has 6 electrons in its outer shell. Atom Y has 7 electrons in its outer shell. When they react, the type of bonding involved and the most likely formula for the compound is

	Bonding type	**Formula**
A.	ionic	X_2Y
B.	ionic	XY_2
C.	covalent	X_2Y
D.	**covalent**	$\mathbf{XY_2}$

Answer is D.

Explanatory notes

- D is correct because atoms with 6 and 7 electrons in their outer shell will be non-metal atoms. When such atoms bond they achieve stability by sharing electrons in a covalent bond. Atom X requires 2 electrons for stability, Y needs only 1, so will share only 1. Two Y atoms are required for each atom of X.
- A is incorrect because atoms with 6 and 7 electrons in their outer shell will be non-metal atoms and so bond with covalent bonds. Also the ratio of X to Y atoms will be 1 : 2, not 2 : 1.
- B is incorrect because atoms with 6 and 7 electrons in their outer shell will be non-metal atoms and so bond with covalent bonds.
- C is incorrect because the ratio of X to Y atoms will be 1 : 2, not 2 : 1.

Tip

- *Assign element symbols to atoms X and Y to assist in visualising the compound formed. For example:*

  Atom X is a Group 6 element such as O, S.

  Atom Y is a Group 7 element such as F, Cl.

Question 15

Polyethene is an addition polymer that can exist in both high-density and low-density forms. Compared to the low-density form, the high-density form is

A. highly branched with a high melting temperature.

B. highly branched with a low melting temperature.

C. **unbranched with a high melting temperature.**

D. unbranched with a low melting temperature.

Answer is C.

Explanatory notes

- C is correct because unbranched polyethene molecules are able to pack together more closely, giving it the high density. It will have a higher melting temperature because it is harder to separate the more tightly packed molecules from each other, so higher temperatures are required.
- A is incorrect because it is the unbranched polyethene molecules that are able to pack together more closely, giving it high density.
- B is incorrect because it is the unbranched polyethene molecules that are able to pack together more closely, giving it high density.
- D is incorrect because the unbranched chains pack closely together and require a high melting temperature to separate them.

Question 16

The name of a molecule with the formula C_4H_8 could be

A. **1-butene**

B. butane

C. 1-propene

D. propane

Answer is A.

Explanatory notes

- A is correct because C_4H_8 has the general formula of alkenes, which is C_nH_{2n}, giving it the suffix *-ene*. It also contains 4 carbon atoms, giving it the prefix *but-*.
- B is incorrect because it has the suffix *–ane*, whereas the formula C_4H_8 represents an alkene.
- C is incorrect because for the molecule to be named using *prop-* as a prefix its full name would need to be 2-methyl-propene.
- D is incorrect because it has the suffix *–ane*, whereas the formula C_4H_8 represents an alkene.

Question 17

Which of the following groups only contains molecules that have a linear shape?

A. HCl, H_2O, N_2

B. NH_3, O_2, CO_2

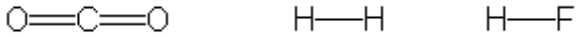
C. **CO_2, H_2, HF**

D. HCl, HF, CH_4

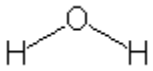
Answer is C.

Explanatory notes

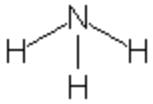
- C is correct. The linear shapes of the molecules are shown below.



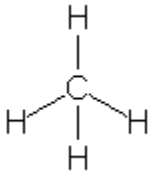
- A is incorrect because H_2O is V-shaped or angular or bent.



- B is incorrect because NH_3 is trigonal pyramidal.



- D is incorrect because methane is tetrahedral.



Question 18

A new material has been discovered. Experimental tests determine that it has a melting temperature of 750°C, can conduct electricity when molten and is brittle when hit with a hammer. The strongest bonding type present in the material is most likely to be

A. ionic

B. covalent

C. metallic

D. hydrogen

Answer is A.

Explanatory notes

- A is correct because although metallic and ionic substances can both conduct electricity when molten, only ionic substances are brittle, whereas metallic substances are malleable.
- B is incorrect because although covalent bonding is the intramolecular bonding formed when non-metal atoms share electrons to form structures with a very high melting point and brittle covalent network lattices, these covalent network lattices cannot conduct electricity when molten.
- C is incorrect because metallic substances are malleable when hit with a hammer – not brittle.
- D is incorrect because hydrogen bonding is an intermolecular force between polar covalent molecules that can form bonds between hydrogen atoms. Covalent molecules have a low boiling temperature, cannot conduct electricity when molten and are not brittle.

Question 19

Which of the following groups contains only polar molecules?

A. HCl, H_2O, N_2, CO_2

B. H_2O, CO_2, NH_3, HF

C. HF, H_2O, NH_3, CH_4

D. **HCl, HF, H_2O, NH_3**

Answer is D.

Explanatory notes

- D is correct because these molecules are all polar, meaning that each contains polar bonds and has partial charges distributed asymmetrically across the molecule, meaning that the bond dipoles do not cancel out.
- A is incorrect because N_2 and CO_2 are both non-polar molecules. N_2 does not contain polar bonds because there is no unequal sharing of electrons and, although CO_2 contains polar bonds, the partial charges are distributed symmetrically (i.e. the bond dipoles cancel out), so the molecule is not polar.
- B is incorrect because CO_2 is non-polar. Although it contains polar bonds, the partial charges are distributed symmetrically (i.e. the bond dipoles cancel out), so the molecule is not polar.
- C is incorrect because CH_4 is non-polar. Although it contains polar bonds, the partial charges are distributed symmetrically (i.e. the bond dipoles cancel out), so the molecule is not polar.

Question 20

Particles at the surface of a material often behave very differently to the particles that are part of the bulk of the material. The best explanation of this is that particles at the surface of a material

A. react with water in the atmosphere, which changes their properties.

B. **do not bond to as many surrounding particles as those in the bulk of the material.**

C. bond more strongly to their surrounding particles than those in the bulk of the material.

D. can break away easily from their surrounding materials.

Answer is B.

Explanatory notes

- B is correct because particles at the surface of a material are not entirely surrounded by other particles and so have 'incomplete' bonds.
- A is incorrect because particles at the surface of a material do not necessarily react with water in the atmosphere.
- C is incorrect because the type and strength of the bonds between particles at the surface and their surrounding particles is no different to the type and strength of bonds in the bulk of the material.
- D is incorrect because particles at the surface cannot necessarily break away easily from their surrounding materials.

END OF SECTION A

SECTION B – Short-answer questions

Question 1

a. The current model of the atom has developed historically through the contributions of a number of individuals.

i. Give the name of one individual who has contributed to the historical development of the model of the atom.

ii. Describe the contribution made by this individual.

Solution

Students should select any one individual from the following:

i. Dalton **ii.** Proposed that matter is made up of tiny, indivisible particles.

i. Thomson **ii.** Proposed that atoms are positively charged spheres with electrons embedded in them.

i. Rutherford **ii.** Developed the nuclear model; that is, the atom is mostly empty space with a positively charged nucleus with orbiting electrons.

i. Bohr **ii.** Placed electrons into certain orbits of fixed energy called shells.

i. Schrödinger **ii.** Proposed that electrons behave as negative clouds of charge found in regions of space called orbitals.

i. Chadwick **ii.** Identified the neutron; that is, proposed that the nucleus contains positive protons and neutral neutrons.

2 marks

Mark allocation

- 1 mark for the correct name of an individual.
- 1 mark for correctly stating the contribution made by the individual nominated in part **i**.

b. Argon has three naturally occurring isotopes. Their relative abundances and masses are shown in the table below.

	Relative isotopic mass	**Percentage abundance**
^{36}Ar	35.968	0.3365
^{38}Ar	37.963	0.0632
^{40}Ar	39.962	99.6003

i. What is the name of the instrument that is commonly used to experimentally obtain abundance and relative isotopic mass data?

Solution

mass spectrometer

ii. Using the information in the table, determine the relative atomic mass of argon. Show your working and give your answer to the appropriate number of significant figures.

Solution

$$A_r = \frac{\text{(\% abundance} \times \text{relative mass) + (\% abundance} \times \text{relative mass)}}{100}$$

$$A_r(\text{Ar}) = \frac{35.968 \times 0.3365 + 37.963 \times 0.0632 + 39.962 \times 99.6003}{100}$$

$$= \frac{12.103 + 2.3993 + 3980.23}{100}$$

$$= \frac{3994.7}{100}$$

$$= 39.947$$

$$= 39.9 \text{ (correct to 3 significant figures)}$$

3 marks

Mark allocation

- 1 mark for mass spectrometer.
- 1 mark for showing correct calculations.
- 1 mark for answer of 39.9, correct to 3 significant figures.

Explanatory notes

- Numerical answers should always be expressed with the same number of significant figures as the least precise piece of given data. In this question, the least precise data was the percentage abundance of 0.0632, which has 3 significant figures. Hence, the correctly expressed answer has 3 significant figures.

c. The atomic number of potassium is 19.

i. Write the electron configuration, in terms of shells and subshells, for the potassium atom in its ground state.

Solution

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

ii. Write the electron configuration, in terms of shells and subshells, for the K^+ ion.

Solution

$1s^2 2s^2 2p^6 3s^2 3p^6$

2 marks

Mark allocation

- 1 mark for part **i**.
- 1 mark for part **ii**.

Explanatory notes

- The potassium atom is neutral and contains 19 electrons. The K^+ ion has a positive charge because it has lost one electron so has a total of 18. The electron is lost from the outermost shell, which in this case is 4s.

Total 2 + 3 + 2 = 7 marks

Question 2

The Periodic Table is an extremely useful framework for displaying the known elements and information about their properties.

a. i. Give the name of an individual who has made a contribution to the modern Periodic Table.

ii. Describe the contribution made by this individual.

Solution

Students must select any one individual from the following:

i.	Mendeleev	**ii.**	Devised the first Periodic Table in which elements were arranged in order of increasing atomic mass and elements with similar chemical properties were grouped together.
i.	Rayleigh	**ii.**	Discovered and added the noble gases.
i.	Ramsay	**ii.**	Discovered and added the noble gases.
i.	Mosely	**ii.**	Rearranged the Periodic Table after the discovery of protons so that elements were placed in order of increasing atomic number instead of increasing atomic mass.
i.	Seaborg	**ii.**	Discovered and added many of the transuranium elements.

2 marks

Mark allocation

- 1 mark for the correct name of an individual.
- 1 mark for correctly stating the contribution made by the individual nominated in part **i.**

b. Use the Periodic Table to write the symbol for each of the following elements:

i. The element that is in Group 2 and Period III.

Solution

Mg

Explanatory notes

- Groups are vertical columns and periods are horizontal rows.

ii. An element from Period V that is located in the s block.

Solution

Rb or Sr

Explanatory notes

- The s block consists of Groups 1 and 2. All of the elements in this block have their outer shell electron(s) in an s subshell.

iii. An element that is in Period IV and is a transition metal.

Solution

Any one of: Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu or Zn

Explanatory notes

- The transition metals make up the d block of the Periodic Table.

iv. A noble gas with 6 occupied shells.

Solution

Rn

Explanatory notes

- The noble gases are the unreactive gases in Group 18. The period an element is in indicates the number of occupied electron shells it has. An element with 6 occupied shells is located in Period 6.

v. The element from Period III with the largest atomic radius.

Solution

Na

Explanatory notes

- Atomic radius decreases from left to right across a period as the outer shell electrons are held more tightly to the nucleus due to increasing core charge.

vi. The element that has 4 occupied shells and 2 electrons in its outer shell.

Solution

Ca

Explanatory notes

- The number of occupied shells indicates the period an element is in and the number of electrons in the outer shell indicates the group.

6 marks

Mark allocation

- 1 mark for each correct symbol.

c. i. State whether the trend in metallic character of elements increases or decreases from left to right across the Periodic Table.

Solution

Metallic character decreases.

ii. Give a brief explanation for this trend.

Solution

Moving left to right across a period, the core charge is increasing, meaning the outer shell electrons are being held more tightly to the atom. As the outer shell electrons are becoming harder to lose or delocalise from left to right in the table, the metallic character decreases.

3 marks

Mark allocation

- 1 mark for metallic character decreases.
- 1 mark for core charge increases from left to right.
- 1 mark for electrons are becoming harder to lose or delocalise.

Total 2 + 6 + 3 = 11 marks

Question 3

A sample of sodium carbonate (Na_2CO_3) has a mass of 16.6 g.

a. Calculate the amount, in mol, of sodium carbonate present.

Solution

$$n(Na_2CO_3) = \frac{m}{M}$$
$$= \frac{16.6}{(2\times 23 + 12.0 + 3\times 16.0)}$$
$$= \frac{16.6}{106}$$
$$= 0.157 \text{ mol}$$

2 marks

Mark allocation

- 1 mark for correctly using the value of 106 g mol^{-1} for molar mass of Na_2CO_3.
- 1 mark for correct calculation of amount, in mol.

b. Calculate the amount, in mol, of sodium atoms present.

Solution

n(Na atoms) = $n(Na_2CO_3)$ × the number of Na atoms in the formula
= 0.157 × 2
= 0.314 mol

1 mark

c. Calculate the total number of atoms present.

Solution

n(atoms) = $n(Na_2CO_3)$ × the total number of atoms in the formula
= 0.157 × (2 sodium atoms + 1 carbon atom + 3 oxygen atoms)
= 0.157 × 6 atoms
= 0.940 mol
N(atoms) = n(atoms) × N_A
= $0.940 \times 6.02 \times 10^{23}$
= 5.66×10^{23} atoms

2 marks

Mark allocation

- 1 mark for recognising that there are 6 atoms in the formula.
- 1 mark for correct calculation of total number of atoms.

d. Determine the percentage, by mass, of oxygen in sodium carbonate.

Solution

$$\% \text{ by mass} = \frac{\text{Mass of the element in 1 mol of the compound}}{\text{Molar mass of the compound}} \times 100$$

$$\% \text{ O} = \frac{3 \times 16.0}{(2 \times 23.0 + 12.0 + 3 \times 16.0)} \times 100$$

$$= \frac{48.0}{106} \times 100$$

$$= 45.3\%$$

2 marks

Mark allocation

- 1 mark for correctly calculating total mass of oxygen is 48.0.
- 1 mark for correct calculation of percentage by mass.

Total 2 + 1 + 2 + 2 = 7 marks

Question 4

Give concise explanations for each of the following:

a. Metallic substances are good conductors of electricity.

Solution

Metallic lattices contain delocalised electrons that are free to move and carry charge.

1 mark

Explanatory notes

The metallic lattice is a regular arrangement of metal cations surrounded by a sea of delocalised electrons. The delocalised electrons are released from the outer shell of the metal atoms when they become cations and form the lattice.

Tips

- *Remember that the conduction of electricity requires that free-moving charged particles be present, which can be either ions or electrons.*

b. Ionic substances cannot conduct electricity when solid but can when molten or aqueous.

Solution

In the solid state, ionic substances contain charged particles in a fixed lattice structure. These ions are not free-moving, so the ionic substance cannot conduct electricity. When molten or aqueous, the anions and cations are free to move and so can conduct electricity.

2 marks

Mark allocation

- 1 mark for stating that no free-moving particles are present in the solid state.
- 1 mark for stating that free-moving anions and cations are present when molten or aqueous.

Explanatory notes

The solid ionic lattice is a regular arrangement of metal cations and non-metal anions, formed when the metal atoms donated their outer shell electrons to non-metal atoms. There are no free-moving charged particles. When ionic substances are dissolved or molten, the lattice breaks down and the anions and cations are free to move.

c. A methane (CH_4) molecule has a tetrahedral shape.

Solution

The four sets of bonding pairs of electrons in the molecule repel each other due to their negative charges and move the maximum distance apart. The resulting shape is tetrahedral.

2 marks

Mark allocation

- 1 mark for stating that bonding pairs repel each other.
- 1 mark for stating that tetrahedral shape gives maximum separation.

Total 1 + 2 + 2 = 5 marks

Question 5

a. Write the name and molecular formula of an alkane that has 3 carbon atoms.

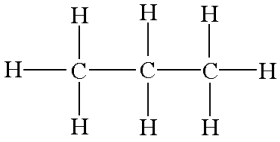
Solution

propane, C_3H_8

1 mark

Explanatory notes

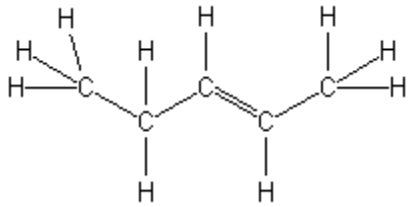
An alkane with 3 carbons has only one possible structural formula:



The 3 carbons in the longest chain give the prefix *prop-*.

b. Draw the structure of 2-pentene.

Solution



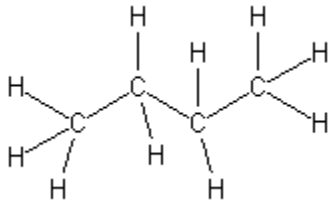
1 mark

Explanatory notes

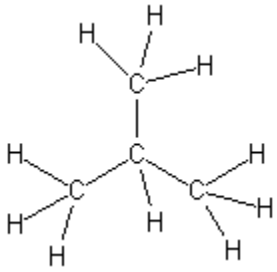
- The suffix *-ene* indicates the molecule is an alkene, meaning it contains a double bond. The prefix *pent-* indicates there are 5 carbon atoms and the 2- indicates the double bond is located starting from the second carbon atom.

c. Draw the structures and give the names of all of the structural isomers of C_4H_{10}.

Solution



butane



2-methyl propane

4 marks

Mark allocation

- 1 mark for each correct structure.
- 1 mark for each correct name.

Explanatory notes

- Structural isomers have the same molecular formula but differ in their structural formula.

d. Alkanes and alkenes are both examples of a homologous series. Give a definition of the term 'homologous series'.

Solution

A homologous series is a group of hydrocarbons in which successive members differ by $–CH_2–$.

1 mark

e. Explain why alkanes are non-polar molecules.

Solution

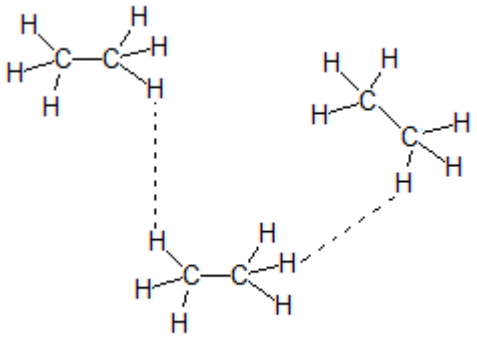
Although the C–H bonds are polarised they are distributed symmetrically across the molecule, so the bond polarities cancel out.

1 mark

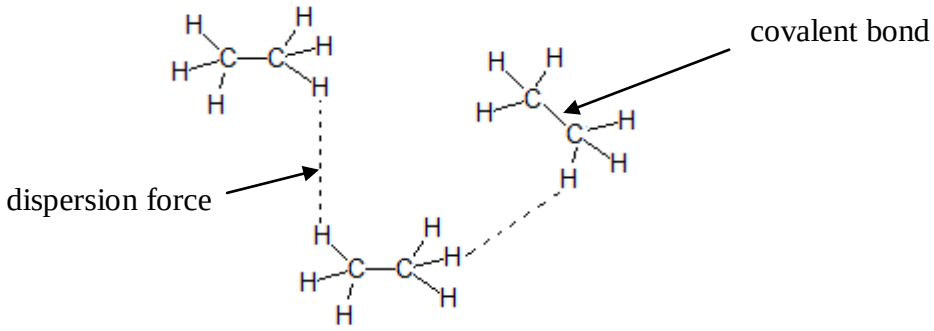
Explanatory notes

- A non-polar molecule either does not contain any polarised bonds or does contain polarised bonds that are distributed symmetrically across the molecule, meaning the bond polarities cancel out and the molecule does not have ends with different partial charges.

f. Consider the diagram below, which represents a number of ethane molecules. Clearly label and name the different types of bonding present.



Solution



2 marks

Mark allocation

- 1 mark for dispersion force named and correctly labelled.
- 1 mark for covalent bond named and correctly labelled.

Explanatory notes

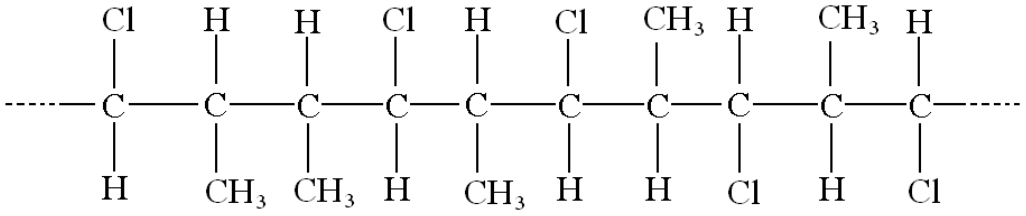
- The constituent atoms of ethane (i.e. C and H) are both non-metal atoms, so the intramolecular bonds are covalent bonds resulting from the sharing of electrons. The ethane molecule is non-polar, so the only intermolecular bonds are dispersion forces.

Total 1 + 1 + 4 + 1 + 1 + 2 = 10 marks

Question 6

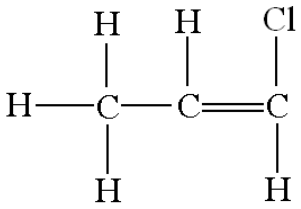
Polymers are very large covalent molecular substances.

a. Below is a representation of an addition polymer.



Draw the structure of the monomer from which this polymer was formed.

Solution



1 mark

Explanatory notes

- A monomer used to make an addition polymer must be unsaturated. This one has a Cl and an H atom attached to a carbon atom on one side of the double bond and a CH_3 group and an H atom attached to the carbon on the other side (i.e. the monomer contains 3 carbon atoms).

Tip

- *To split an addition polymer into its monomers, pair off the carbons in the central chain and add a double bond between them.*

b. Describe a simple experiment you could perform to determine if a particular polymer was thermosetting or thermoplastic. Describe the results you would expect for both types of polymer.

Solution

Use tongs to heat the polymer over a flame. If it softens and melts it is thermoplastic. If it chars and blackens it is thermosetting.

3 marks

Mark allocation

- 1 mark for heat the polymer.
- 1 mark for description of results for thermoplastic.
- 1 mark for description of results for thermosetting.

c. Describe the main structural difference between thermosetting and thermoplastic polymers.

Solution

Thermosetting polymers have strong covalent bonds, called cross-links, between different polymer chains.

Thermoplastic polymers have only weak forces between different chains.

2 marks

Mark allocation

- 1 mark for each correct description.

d. Customised polymers are polymers designed and produced for a particular task. Give **one** way in which a customised polymer can be produced.

Solution

Any one of the following:

- Use two different monomers.
- Alter the structure of side groups.
- Change the arrangement of side groups.
- Use additives.

1 mark

Total 1 + 3 + 2 + 1 = 7 marks

END OF SOLUTIONS BOOK