Kirkcaldy High School

Chemistry

Higher

Unit 1 – Chemical Changes and Structure

TUTORIAL QUESTIONS

(a) Periodicity

1.

The difference between the atomic size of sodium and chlorine is mainly due to the difference in the

A number of electrons

B number of protons

C number of neutrons

D mass of each atom.

2.

Which entry in the table shows the trends in the electronegativity values of the elements in the Periodic Table?

	Across a period	**Down a group**
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

3.

Which type of structure is found in a fullerene?

A Ionic lattice

B Metallic lattice

C Covalent network

D Covalent molecular

4.

Which of the following elements exists as discrete molecules?

A Boron

B Carbon (diamond)

C Silicon

D Sulphur

5.

Which of the following elements has the greatest electronegativity?

A Caesium

B Oxygen

C Fluorine

D Iodine

6.

Which of the following equations represents the first ionisation energy of chlorine?

A $Cl(g) + e^- \rightarrow Cl^-(g)$

B $Cl^+(g) + e^- \rightarrow Cl(g)$

C $Cl(g) \rightarrow Cl^+(g) + e^-$

D $Cl^-(g) \rightarrow Cl(g) + e^-$

7.

Which of the following has a covalent molecular structure?

A Radium chloride

B A noble gas

C Silicon dioxide

D A fullerene

8.

Which element is a solid at room temperature and consists of discrete molecules?

A Carbon

B Silicon

C Sulphur

D Boron

9.

Graphite, a form of carbon, conducts electricity because it has

A metallic bonding

B van der Waals bonding

C delocalised electrons

D pure covalent bonding.

10.

The difference between the covalent radius of sodium and silicon is mainly due to the difference in the

A number of electrons

B number of protons

C number of neutrons

D mass of each atom.

11.

A potassium atom is larger than a sodium atom because potassium has

A a larger nuclear charge

B a larger nucleus

C more occupied energy levels

D a smaller ionisation energy.

12.

Which of the processes represents the second ionisation energy of magnesium?

A $Mg^{+}(g) \rightarrow Mg^{2+}(g) + e$

B $Mg(g) \rightarrow Mg^{2+}(g) + 2e$

C $Mg(s) \rightarrow Mg^{2+}(g) + 2e$

D $Mg^{+}(s) \rightarrow Mg^{2+}(s) + e$

13.

Which of the following statements is true?

A The potassium ion is larger than the potassium atom.

B The chloride ion is smaller than the chlorine atom.

C The sodium atom is larger than the sodium ion.

D The oxygen atom is larger than the oxide ion.

14.

Which of the following equations represents the first ionisation energy of fluorine?

A $F^{-}(g) \rightarrow F(g) + e^{-}$

B $F^{-}(g) \rightarrow \frac{1}{2}F_2(g) + e^{-}$

C $F(g) \rightarrow F^{+}(g) + e^{-}$

D $\frac{1}{2}F_2(g) \rightarrow F^{+}(g) + e^{-}$

15.

Which of the following elements has the smallest electronegativity?

A Lithium

B Caesium

C Fluorine

D Iodine

16.

As the atomic number of the alkali metals increases

A the first ionisation energy decreases

B the atomic size decreases

C the density decreases

D the melting point increases.

17.

Which of the following atoms has the least attraction for bonding electrons?

A Carbon

B Nitrogen

C Phosphorus

D Silicon

18.

Which of the following reactions refers to the third ionisation energy of aluminium?

A $Al(s) \rightarrow Al^{3+}(g) + 3e^{-}$

B $Al(g) \rightarrow Al^{3+}(g) + 3e^{-}$

C $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$

D $Al^{3+}(g) \rightarrow Al^{4+}(g) + e^{-}$

19.

Which of the following elements has the greatest attraction for bonding electrons?

A Lithium

B Chlorine

C Sodium

D Bromine

20.

As the relative atomic mass in the halogens increases

A the boiling point increases

B the density decreases

C the first ionisation energy increases

D the atomic size decreases.

21.

The table shows the first three ionisation energies of aluminium.

Ionisation energy/kJ mol^{-1}		
1st	**2nd**	**3rd**
584	1830	2760

Using this information, what is the enthalpy change, in kJ mol^{-1}, for the following reaction?

$$Al^{3+}(g) + 2e^- \rightarrow Al^{+}(g)$$

A +2176

B –2176

C +4590

D –4590

22.

Which of the following elements exists as discrete molecules?

A Boron

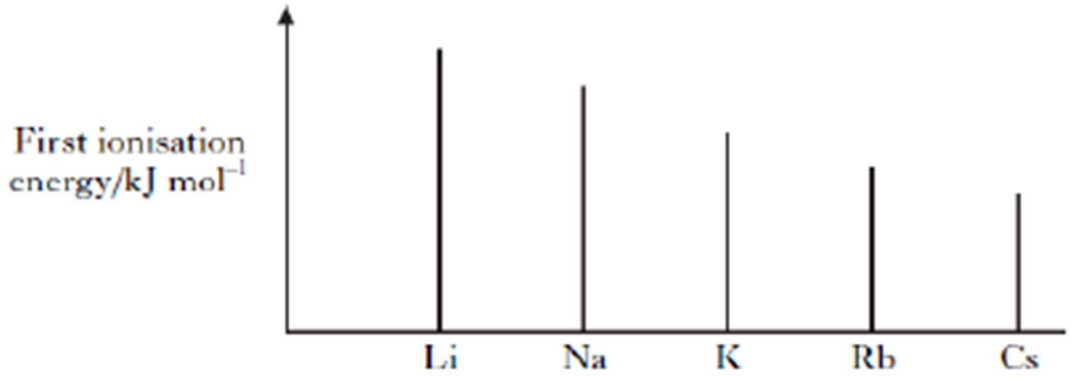
B Carbon (diamond)

C Silicon

D Sulfur

23. The first ionisation energy of an element is defined as the energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

The graph shows the first ionisation energies of the Group 1 elements



(a) Explain fully why the first ionisation energy decreases down this group.

(b) The ability of an atom to form a negative ion is measured by its Electron Affinity.

The Electron Affinity is defined as the energy change when one mole of gaseous atoms of an element combines with one mole of electrons to from gaseous negative ions.

Write the equation, showing state symbols that represents the Electron Affinity of chlorine.

24.

(*a*) Atoms of different elements have different attractions for bonded electrons.

What term is used as a measure of the attraction an atom involved in a bond has for the electrons of the bond?

(*b*) Atoms of different elements are different sizes.

What is the trend in atomic size across the period from sodium to argon?

(*c*) Atoms of different elements have different ionisation energies.

Explain clearly why the first ionisation energy of potassium is less than the first ionisation energy of sodium.

25.

The elements lithium to neon make up the second period of the Periodic Table.

Li	Be	B	C	N	O	F	Ne

(*a*) Name an element from the second period that exists as a covalent network.

(*b*) Why do the atoms decrease in size from lithium to neon?

26.

The elements from sodium to argon make up the third period of the Periodic Table.

(*a*) On crossing the third period from left to right there is a general increase in the first ionisation energy of the elements.

(i) Why does the first ionisation energy increase across the period?

(ii) Write an equation corresponding to the first ionisation energy of chlorine.

(*b*) The electronegativities of elements in the third period are listed on page 10 of the databook.

Why is no value provided for the noble gas, argon?

27.

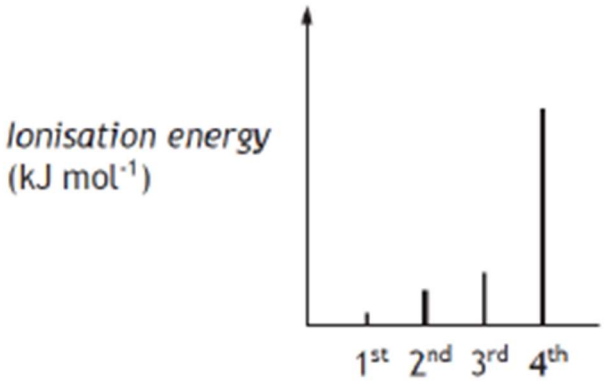
Sodium is the first element in the third period of the periodic table.

Na	Mg	Al	Si	P	S	Cl	Ar

(a) Describe the trend in electronegativity values across this period from Na to Cl.

(b) Name the element in the third period that has a covalent network structure.

(c) The spike graph shows the first four ionisation energies for aluminium.



Explain why the fourth ionisation energy of aluminium is much higher than the third ionisation energy.

28.

Common salt, NaCl, is widely used in the food industry as a preservative and flavour enhancer.

(a) (i) Write the ion-electron equation for the first ionisation energy of sodium.

(ii) **Explain clearly** why the first ionisation energy of sodium is much lower than its second ionisation energy.

(b) The label on a tub of margarine states that 100 g of the margarine contains 0·70 g of sodium. The sodium is present as sodium chloride.

Calculate the mass of sodium chloride, in grams, present in a 10 g portion of the margarine.

The mass of one mole of sodium chloride, NaCl, is 58·5 g.

29.

Information about four elements from the third period of the Periodic Table is shown in the table.

Element	aluminium	silicon	phosphorus	sulfur
Bonding		covalent		covalent
Structure	lattice		molecular	

(*a*) Complete the table to show the bonding and structure for each element.

(*b*) Why is there a decrease in the size of atoms across the period from aluminium to sulfur?

30. Attempts have been made to make foods healthier by using alternatives to traditional cooking ingredients.

An alternative to common salt contains potassium ions and chloride ions.

(c) Write an ion-electron equation for the first ionisation energy of potassium

(d) Explain fully why the first ionisation energy of potassium is smaller than that of chlorine.

31.

In 1996, the scientists Robert Curl, Harold Kroto and Richard Smalley won the Nobel Prize in Chemistry for their contribution to the discovery of new forms of carbon called fullerenes.

(*a*) In what way does the structure of fullerenes differ from the other forms of carbon, diamond and graphite?

(*b*) One form of fullerene, C_{60}, forms a superconducting crystalline compound with potassium.

Its formula can be represented as K_3C_{60}.

A sample of this compound was found to contain 2·88 g of carbon.

(i) Calculate the number of moles of fullerene used to make this compound.

(ii) Calculate the mass of potassium, in grams, in the sample.

32. Ionisation energies provide information about the structure of atoms.

(e) Write the equation, showing state symbols, for the first ionisation energy of sodium.

(f) Calculate the energy required to convert one mole of boron atoms into one mole of boron ions with a charge of 3+.

(g) State the type of bonding present in boron.

33.

On crossing the Periodic Table, there are trends in the sizes of atoms and ions.

(*a*) Why is the atomic size of chlorine less than that of sodium?

(*b*)

Ion	Ionic radius/pm
Si^{4+}	42
P^{3-}	198

Why is there a large increase in ionic radius on going from Si^{4+} to P^{3-}?

34.

The following answer was taken from a student's examination paper.
The answer is incorrect.
Give the correct explanation

Question Explain the difference in atomic size between potassium and chlorine atoms.

Student answer A potassium nucleus has 19 protons but a chlorine nucleus has only 17 protons. The greater pull on the outer electron in the potassium atom means the atomic size of potassium is less than that of chlorine.

Correct explanation

35.

The elements lithium, boron and nitrogen are in the second period of the Periodic Table.

Complete the table below to show **both** the bonding and structure of these three elements at room temperature.

Name of element	Bonding	Structure
lithium		lattice
boron		
nitrogen	covalent	

36.

The three statements below are taken from a note made by a student who is studying trends in the Periodic Table.

1 First Ionisation Energy

The energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

2 Second Ionisation Energy

The energy required to remove a second mole of electrons.

3 _____

The measure of the attraction an atom has for the shared electrons in a bond.

(*a*) Complete the note above to give the heading for the third statement.

(*b*) What is the trend in the first ionisation energy across a period from left to right?

(*c*) Why is the second ionisation energy of sodium so much greater than its first ionisation energy?

37.

(*a*) Complete the table below by adding the name of an element from **elements 1 to 20** of the Periodic Table for each of the types of bonding and structure described.

Bonding and structure at room temperature and pressure	**Name of element**
metallic solid	sodium
monatomic gas	
covalent network solid	
discrete covalent molecular gas	
discrete covalent molecular solid	

(*b*) Why do metallic solids such as sodium conduct electricity?

38.

Diamond and graphite are forms of carbon with very different properties. Graphite can mark paper, is a lubricant and is a conductor of electricity. Diamond has none of these properties.

(*a*) Draw a diagram to show the structure of diamond.

(*b*) Why is graphite an effective lubricant?

39.

Particles with the same electron arrangement are said to be isoelectronic.

Which of the following compounds contains ions which are isoelectronic?

A Na_2S

B $MgCl_2$

C KBr

D $CaCl_2$

(b) Structure and bonding

1.

Which type of bonding is **never** found in elements?

A Metallic
B London dispersion forces
C Polar covalent
D Non-polar covalent

2.

Which type of bonding can be described as intermolecular?

A Covalent
B Hydrogen
C Ionic
D Metallic

3.

Which chloride is most likely to be soluble in tetrachloromethane, CCl_4?

A Barium chloride
B Caesium chloride
C Calcium chloride
D Phosphorus chloride

4.

Which of the following compounds has polar molecules?

A CH_4
B CO_2
C NH_3
D CCl_4

5.

What type of bond is broken when ice is melted?

A Ionic
B Polar covalent
C Hydrogen
D Non-polar covalent

6.

As the relative atomic mass in the halogens increases

A the boiling point increases
B the density decreases
C the first ionisation energy increases
D the atomic size decreases.

7.

Which of the following elements would have the strongest London dispersion forces?

A Argon
B Chlorine
C Nitrogen
D Oxygen

8.

Which of the following structures is **never** found in compounds?

A Ionic
B Monatomic
C Covalent network
D Covalent molecular

9.

Which type of structure is found in a fullerene?

A Ionic lattice

B Metallic lattice

C Covalent network

D Covalent molecular

10.

Which type of bonding can be described as intermolecular?

A Covalent bonding

B Hydrogen bonding

C Ionic bonding

D Metallic bonding

11.

An element melts at about room temperature and forms an oxide which reacts with water to form a solution with a pH less than 7.

Which statement is most likely to be true?

A The element conducts electricity.

B The oxide contains covalent bonds.

C The oxide has a high melting point.

D The element has a covalent network structure.

12.

For elements in Group 7 of the Periodic Table, which of the following statements is true as the group is descended?

A The boiling point decreases.

B The covalent radius decreases.

C The electronegativity decreases.

D The strength of London dispersion forces decreases.

13.

Which of the following does **not** contain covalent bonds?

A Hydrogen gas

B Helium gas

C Nitrogen gas

D Solid sulphur

14.

When two atoms form a non-polar covalent bond, the two atoms **must** have

A the same atomic size

B the same electronegativity

C the same ionisation energy

D the same number of outer electrons.

15.

In which of the following solvents is lithium chloride most likely to dissolve?

A Hexane

B Benzene C_6H_6

C Methanol

D Tetrachloromethane

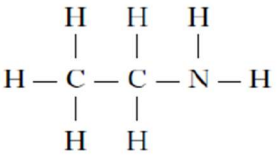
16.

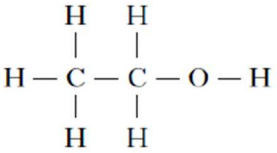
Which line in the table shows the correct entries for tetrafluoroethene?

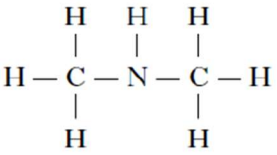
	Polar bonds?	**Polar molecules?**
A	yes	yes
B	yes	no
C	no	no
D	no	yes

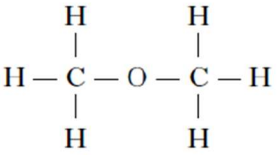
17.

In which of the following compounds would hydrogen bonding **not** occur?

A 

B 

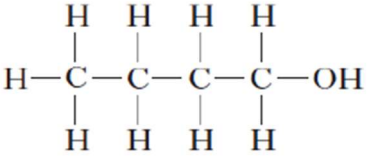
C 

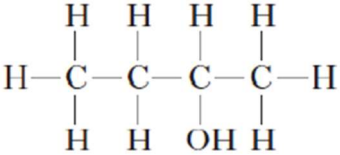
D 

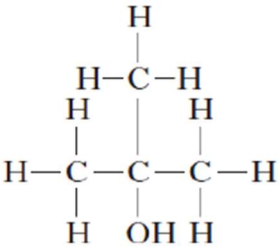
18.

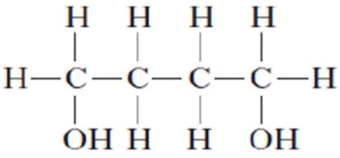
The structures for molecules of four liquids are shown below.

Which liquid will be the most viscous?

A 

B 

C 

D 

19.

The two hydrogen atoms in a molecule of hydrogen are held together by

A a hydrogen bond

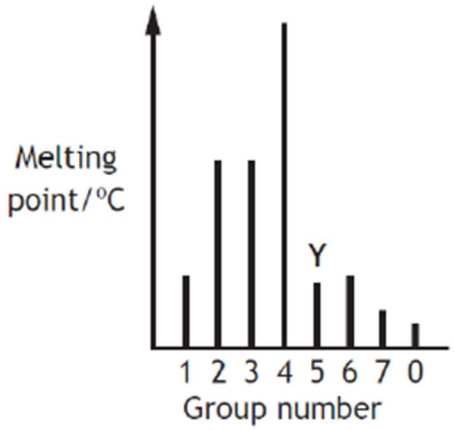
B a polar covalent bond

C a non-polar covalent bond

D a van der Waals' force.

20.

The diagram shows the melting points of successive elements across a period in the Periodic Table.



Which of the following is a correct reason for the low melting point of element Y?

A It has weak ionic bonds

B It has weak covalent bonds

C It has weakly-held outer electrons

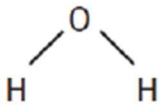
D It has weak forces between molecules

21.

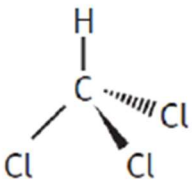
The shapes of some common molecules are shown below and each contains at least one polar bond.

Which molecule is non-polar?

A O = C = O

B 

C H — Cl

D 

22.

Which type of bonding is never found in elements?

A Metallic
B London dispersion forces
C Polar covalent
D Non-polar covalent

23.

For elements in Group 7 of the Periodic Table, which of the following statements is true as the group is descended?

A The boiling point decreases.
B The covalent radius decreases.
C The electronegativity decreases.
D The strength of London dispersion forces decreases.

24.

Which of the following elements has the greatest attraction for bonding electrons?

A Lithium
B Chlorine
C Sodium
D Bromine

25.

Which of the following is **not** an example of a Van der Waals' force?

A Covalent bonding
B Hydrogen bonding
C London dispersion forces
D Permanent dipole-permanent dipole interactions

26.

In which of the following molecules will the chlorine atom carry a partial positive charge ($\delta+$)?

A Cl—Br
B Cl—Cl
C Cl—F
D Cl—I

27.

The boiling point of hydrogen fluoride, HF, is much higher than the boiling point of F_2.

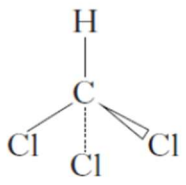
H — F	F — F
boiling point: 19·5 °C	boiling point: −188 °C

Explain fully why the boiling point of hydrogen fluoride is much higher than the boiling point of fluorine.

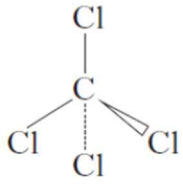
In your answer you should mention the intermolecular forces involved and how they arise.

28.

The structures below show molecules that contain chlorine atoms.



trichloromethane



tetrachloromethane

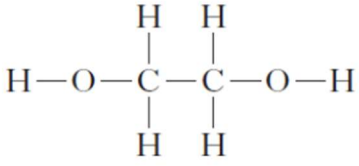
The compounds shown above are not very soluble in water. Trichloromethane is around ten times more soluble in water than tetrachloromethane.

Explain clearly why trichloromethane is more soluble in water than tetrachloromethane.

Your answer should include the names of the intermolecular forces involved.

29.

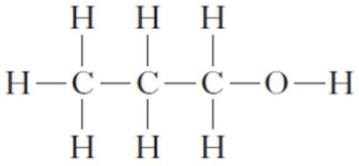
Alcohols are widely used in antifreeze and de-icers.



ethane-1,2-diol

molecular mass 62

boiling point 197 °C



propan-1-ol

molecular mass 60

boiling point 98 °C

Why is the boiling point of ethane-1,2-diol much higher than the boiling point of propan-1-ol?

30.

Atoms of nitrogen and element **X** form a bond in which the electrons are shared equally.

Element **X** could be

A carbon

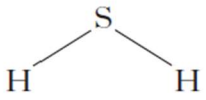
B oxygen

C chlorine

D phosphorus.

31.

Liquid hydrogen sulphide has a boiling point of −60 °C.



Explain clearly why hydrogen sulphide is a gas at room temperature. In your answer, you should name the intermolecular forces involved and indicate how they arise.

32.

A mass spectrometer is an instrument that can be used to gain information about the masses of molecules.

When hydrogen fluoride is analysed in a mass spectrometer, as well as molecules with a relative molecular mass of 20, some "double molecules" (relative molecular mass 40) and "triple molecules" (relative molecular mass 60) are found to exist. No such molecules are found when the elements, hydrogen and fluorine, are separately analysed.

(*a*) Name the weak force of attraction between molecules that is found in both liquid hydrogen and liquid fluorine.

(*b*) Why are "double" and "triple" molecules found in hydrogen fluoride but **not** in hydrogen and **not** in fluorine?

33.

The properties of substances depend on their structures and bonding.

A hydrogen	B phosphorus	C sodium
D lithium hydroxide	E hydrogen fluoride	F hydrogen iodide

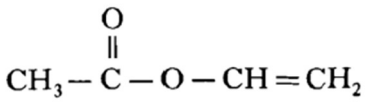
(*a*) Identify the substance with hydrogen bonding between the molecules.

(*b*) Identify the **two** substances with pure covalent bonding in the molecules.

34.

Vinyl acetate is the monomer for the preparation of polyvinylacetate (PVA) which is widely used in the building industry.

Vinyl acetate has the structural formula:



Vinyl acetate and hexane have the same relative formula mass.

Explain why you would expect vinyl acetate to have a higher boiling point than hexane.

35. Hydrogen peroxide has a high viscosity.

The structure of hydrogen peroxide is shown below.

(a) Name the type of intermolecular force that is responsible for hydrogen peroxide's high viscosity.

(b) Draw a diagram to show the intermolecular forces between two molecules of hydrogen peroxide.

(c) Name the alkane molecule that could be compared to hydrogen peroxide to show the difference in intermolecular forces.

36.

The American scientist Linus Pauling devised a scale to compare the attraction of atoms for bonded electrons. This scale is called the electronegativity scale. Some electronegativity values are shown on page 12 of the data booklet.

(*a*) Which group of the Periodic Table contains elements with no quoted values for electronegativity?

(*b*) Use the electronegativity values to explain why carbon disulphide contains pure covalent bonds.

(*c*) Explain the trend in the electronegativity values of the Group 7 elements.

37.

Hydrogen cyanide, HCN, is highly toxic.

Information about hydrogen cyanide is given in the table.

Structure	$H-C\equiv N$
Molecular mass	27
Boiling point	26 °C

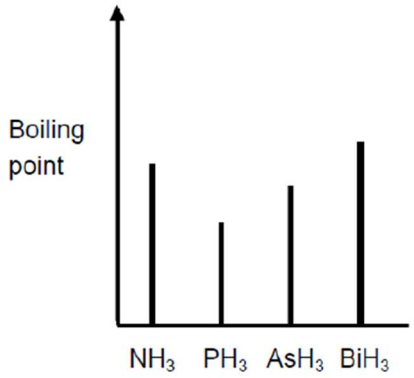
Although hydrogen cyanide has a similar molecular mass to nitrogen, it has a much higher boiling point. This is due to the permanent dipole–permanent dipole attractions in liquid hydrogen cyanide.

What is meant by permanent dipole–permanent dipole attractions?

Explain how they arise in liquid hydrogen cyanide.

38.

The graph shows the boiling points of some of the hydrides in Group 5 of the Periodic Table.

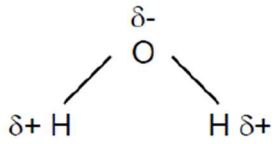


(a) The boiling points of the hydrides increase from PH_3 to BiH_3. Give a reason for this.

(b) Why does NH_3 have an unusually high boiling point?

39.

(a) The polarity of the bonds in a molecule of water is shown in the diagram.



Show the polarity on a molecule of hydrogen bromide.

H ——— Br

(b) Name the most significant intermolecular force that exists between molecules of HBr.

(c) Using electronegativity values given on page 11 in the data booklet, explain why the covalent bond in H – I is less polar than the covalent bond in H – Br.

(c) Oxidising and Reducing Agents

1.

The iodate ion, IO_3^-, can be converted to iodine.

Which is the correct ion-electron equation for the reaction?

A $2IO_3^-(aq) + 12H^+(aq) + 12e^- \rightarrow 2I^-(aq) + 6H_2O(\ell)$

B $IO_3^-(aq) + 6H^+(aq) + 7e^- \rightarrow I^-(aq) + 3H_2O(\ell)$

C $2IO_3^-(aq) + 12H^+(aq) + 11e^- \rightarrow I_2(aq) + 6H_2O(\ell)$

D $2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(aq) + 6H_2O(\ell)$

2.

In which reaction is hydrogen gas acting as an oxidising agent?

A $H_2 + CuO \rightarrow H_2O + Cu$

B $H_2 + C_2H_4 \rightarrow C_2H_6$

C $H_2 + Cl_2 \rightarrow 2HCl$

D $H_2 + 2Na \rightarrow 2NaH$

3.

In which of the following reactions is the hydrogen ion acting as an oxidising agent?

A $Mg + 2HCl \rightarrow MgCl_2 + H_2$

B $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

C $CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$

D $CH_3COONa + HCl \rightarrow NaCl + CH_3COOH$

4.

During a redox process in acid solution, iodate ions are converted into iodine.

$2IO_3^-(aq) + 12H^+(aq) + \mathbf{x}e^- \rightarrow I_2(aq) + 6H_2O(\ell)$

To balance the equation, what is the value of **x**?

A 2

B 6

C 10

D 12

5.

The following reactions take place when nitric acid is added to zinc.

$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

How many moles of $NO_3^-(aq)$ are reduced by one mole of zinc?

A $\frac{2}{3}$

B 1

C $\frac{3}{2}$

D 2

6.

Which of the following is the strongest oxidising agent?

A $Li^+(aq)$

B $Li(s)$

C $F^-(aq)$

D $F_2(g)$

7.

Which of the following is a redox reaction?

A $Mg + 2HCl \rightarrow MgCl_2 + H_2$

B $MgO + 2HCl \rightarrow MgCl_2 + H_2O$

C $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$

D $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

8.

Iodide ions can be oxidised using acidified potassium permanganate solution.

The equations are:

$2I^-(aq) \rightarrow I_2(aq) + 2e^-$

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 1·0

B 2·0

C 2·5

D 5·0

9.

The ion-electron equations for a redox reaction are:

$2I^-(aq) \rightarrow I_2(aq) + 2e^-$

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 0·2

B 0·4

C 2

D 5

10.

During a redox process in acid solution, iodate ions, $IO_3^-(aq)$, are converted into iodine, $I_2(aq)$.

$$IO_3^-(aq) \rightarrow I_2(aq)$$

The numbers of $H^+(aq)$ and $H_2O(\ell)$ required to balance the ion-electron equation for the formation of 1 mol of $I_2(aq)$ are, respectively

A 3 and 6

B 6 and 3

C 6 and 12

D 12 and 6.

11.

One of the reactions taking place within a carbon monoxide sensor is

$2CO + 2H_2O \rightarrow 2CO_2 + 4H^+ + 4e^-$

This reaction is an example of

A reduction

B redox

C oxidation

D hydration.

12.

In which of the following reactions is hydrogen gas acting as an oxidising agent?

A $H_2 + C_2H_4 \rightarrow C_2H_6$

B $H_2 + Cl_2 \rightarrow 2HCl$

C $H_2 + 2Na \rightarrow 2NaH$

D $H_2 + CuO \rightarrow H_2O + Cu$

13.

Silver jewellery discoloured by tarnish (Ag_2S) can be cleaned by placing the item in an aluminium pot containing salt solution. The reaction occurring is shown below.

$3Ag_2S + 2Al \rightarrow 6Ag + Al_2S_3$

Which of the following statements is true?

A Aluminium metal is a reducing agent.

B Silver metal is an oxidising agent.

C Silver ions are acting as electron donors.

D Sulphide ions are acting as electron acceptors.

14.

The ion-electron equations for a redox reaction are:

$2I^-(aq) \rightarrow I_2(aq) + 2e^-$

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 0·2

B 0·4

C 2

D 5

15.

$HgCl_2(aq) + SnCl_2(aq) \rightarrow Hg(\ell) + SnCl_4(aq)$

What ion is oxidised in the above redox reaction?

A $Sn^{2+}(aq)$

B $Sn^{4+}(aq)$

C $Hg^{2+}(aq)$

D $Cl^-(aq)$

16.

. Ammonia reacts with magnesium as shown.

$3Mg(s) + 2NH_3(g) \rightarrow (Mg^{2+})_3(N^{3-})_2(s) + 3H_2(g)$

In this reaction, ammonia is acting as

A an acid

B a base

C an oxidising agent

D a reducing agent.

17.

Which of the following is a redox reaction?

A $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

B $NaOH + HCl \rightarrow NaCl + H_2O$

C $NiO + 2HCl \rightarrow NiCl_2 + H_2O$

D $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

18.

Which of the following elements is the strongest reducing agent?

A Lithium

B Bromine

C Fluorine

D Aluminium

19.

Some fruit drinks claim to be high in antioxidants such as vitamin C.

(*a*) The vitamin C content in a fruit drink can be determined by titrating it with iodine.

The redox reaction which takes place is shown.

$$\underset{\text{vitamin C}}{C_6H_8O_6(aq)} + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$$

(i) Write the ion-electron equation for the oxidation reaction taking place.

(ii) Some students carried out an investigation of fruit drinks to determine their vitamin C content. The following steps were followed in each experiment.

Step 1 A 20·0 cm^3 sample of fruit drink was transferred to a conical flask by pipette.

Step 2 A burette was filled with a standard iodine solution.

Step 3 The fruit drink sample was titrated with the iodine.

Step 4 Titrations were repeated until concordant results were obtained.

The burette, pipette and conical flask were all rinsed before they were used.

Tick the appropriate boxes below to show which solution should be used to rinse each piece of glassware.

Glassware used	Rinse with water	Rinse with iodine	Rinse with fruit drink
pipette			
burette			
conical flask			

19. (cont.)

(a) continued

(iii) Titrating a whole carton of fruit drink would require large volumes of iodine solution.

Apart from this disadvantage, give another reason for titrating several smaller samples of fruit drink.

(iv) An average of 25·4 cm^3 of 0·00125 $mol\,l^{-1}$ iodine solution was required for the complete titration of the vitamin C in a 20·0 cm^3 sample of fruit drink.

Calculate the mass, in grams, of vitamin C in the 1 litre carton of fruit drink.

(mass of 1 mole vitamin C = 176 g)

Show your working clearly.

(*b*) The recommended daily allowance (RDA) for vitamin C is 60 mg.

A one litre carton of an orange fruit drink contains 240 mg of vitamin C.

What percentage of the RDA is provided by 200 cm^3 of this drink?

20.

Solutions containing iodine are used to treat foot rot in sheep.

The concentration of iodine in a solution can be determined by titrating with a solution of thiosulphate ions.

$$I_2 + \underset{\text{thiosulphate ions}}{2S_2O_3^{2-}} \rightarrow 2I^- + S_4O_6^{2-}$$

(*a*) Write an ion-electron equation for the reaction of the oxidising agent in the titration.

(*b*) Three 20·0 cm^3 samples of a sheep treatment solution were titrated with 0·10 mol l^{-1} thiosulphate solution.

The results are shown below.

Sample	Volume of thiosulphate/cm^3
1	18·60
2	18·10
3	18·20

(i) Why is the volume of sodium thiosulphate used in the calculation taken to be 18·15 cm^3, although this is not the average of the three titres in the table?

(ii) Calculate the concentration of iodine, in mol l^{-1}, in the foot rot treatment solution.

Show your working clearly.

21.

When a lead-acid car battery is in use, the following half reaction takes place at the negative electrode:

$$Pb(s) + SO_4^{2-}(aq) \rightarrow Pb^{2+}SO_4^{2-}(s) + 2e^-$$

Complete the ion-electron equation for the reaction taking place at the other electrode.

$$PbO_2(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$$

22.

When copper is added to an acid, what happens depends on the acid and the conditions.

When copper reacts with dilute nitric acid, nitrate ions are reduced.

Complete the ion-electron equation for the reduction of the nitrate ions.

$$NO_3^-(aq) \rightarrow NO(g)$$

23.

Suncreams contain antioxidants.

Another antioxidant used in skin care products is vitamin C, $C_6H_8O_6$.

Complete the ion-electron equation for the oxidation of vitamin C.

$$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq)$$

24.

Seaweeds are a rich source of iodine in the form of iodide ions. The mass of iodine in a seaweed can be found using the procedure outlined below.

(*a*) **Step 1**

The seaweed is dried in an oven and ground into a fine powder. Hydrogen peroxide solution is then added to oxidise the iodide ions to iodine molecules. The ion-electron equation for the reduction reaction is shown.

$$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(\ell)$$

Write a balanced redox equation for the reaction of hydrogen peroxide with iodide ions.

(*b*) **Step 2**

Using starch solution as an indicator, the iodine solution is then titrated with sodium thiosulphate solution to find the mass of iodine in the sample. The balanced equation for the reaction is shown.

$$2Na_2S_2O_3(aq) + I_2(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

In an analysis of seaweed, $14{\cdot}9\,cm^3$ of $0{\cdot}00500\ mol\,l^{-1}$ sodium thiosulphate solution was required to reach the end-point.

Calculate the mass of iodine present in the seaweed sample.

Show your working clearly.

25.

The number of moles of carbon monoxide in a sample of air can be measured as follows.

Step 1 The carbon monoxide reacts with iodine(V) oxide, producing iodine.

$$5CO(g) + I_2O_5(s) \rightarrow I_2(s) + 5CO_2(g)$$

Step 2 The iodine is then dissolved in potassium iodide solution and titrated against sodium thiosulphate solution.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(*a*) Write the ion-electron equation for the oxidation reaction in **Step 2**.

(*b*) Name a chemical that can be used to indicate when all of the iodine has been removed in the reaction taking place in **Step 2**.

(*c*) If 50·4 cm^3 of 0·10 mol l^{-1} sodium thiosulphate solution was used in a titration, calculate the number of moles of carbon monoxide in the sample of air.

Show your working clearly.

26.

Oxalic acid is found in rhubarb. The number of moles of oxalic acid in a carton of rhubarb juice can be found by titrating samples of the juice with a solution of potassium permanganate, a powerful oxidising agent.

The equation for the overall reaction is:

$$5(COOH)_2(aq) + 6H^+(aq) + 2MnO_4^-(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(aq) + 8H_2O(\ell)$$

(*a*) Write the ion-electron equation for the reduction reaction.

(*b*) Why is an indicator **not** required to detect the end-point of the titration?

(*c*) In an investigation using a 500 cm^3 carton of rhubarb juice, separate 25·0 cm^3 samples were measured out. Three samples were then titrated with 0·040 mol l^{-1} potassium permanganate solution, giving the following results.

Titration	Volume of potassium permanganate solution used/cm^3
1	27·7
2	26·8
3	27·0

Average volume of potassium permanganate solution used = 26·9 cm^3.

(i) Why was the first titration result not included in calculating the average volume of potassium permanganate solution used?

(ii) Calculate the number of moles of oxalic acid in the 500 cm^3 carton of rhubarb juice.

Show your working clearly.

27.

Rivers and drains are carefully monitored to ensure that they remain uncontaminated by potentially harmful substances from nearby industries. Chromate ions, CrO_4^{2-}, are particularly hazardous.

The concentration of chromate ions in water can be measured by titrating with a solution of iron(II) sulphate solution.

A 50·0 cm^3 sample of contaminated water containing chromate ions was titrated and found to require 27·4 cm^3 of 0·0200 mol l^{-1} iron(II) sulphate solution to reach the end-point.

The redox equation for the reaction is:

$$3Fe^{2+}(aq) + CrO_4^{2-}(aq) + 8H^+(aq) \rightarrow 3Fe^{3+}(aq) + Cr^{3+}(aq) + 4H_2O(\ell)$$

Calculate the chromate ion concentration, in mol l^{-1}, present in the sample of water.

Show your working clearly.

28.

A major problem for the developed world is the pollution of rivers and streams by nitrite and nitrate ions.

The concentration of nitrite ions, $NO_2^-(aq)$, in water can be determined by titrating samples against acidified permanganate solution.

(*a*) Suggest **two** points of good practice that should be followed to ensure that an accurate end-point is achieved in a titration.

(*b*) An average of $21{\cdot}6\,cm^3$ of $0{\cdot}0150\ mol\,l^{-1}$ acidified permanganate solution was required to react completely with the nitrite ions in a $25{\cdot}0\,cm^3$ sample of river water.

The equation for the reaction taking place is:

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(\ell)$$

(i) Calculate the nitrite ion concentration, in $mol\,l^{-1}$, in the river water.

Show your working clearly.

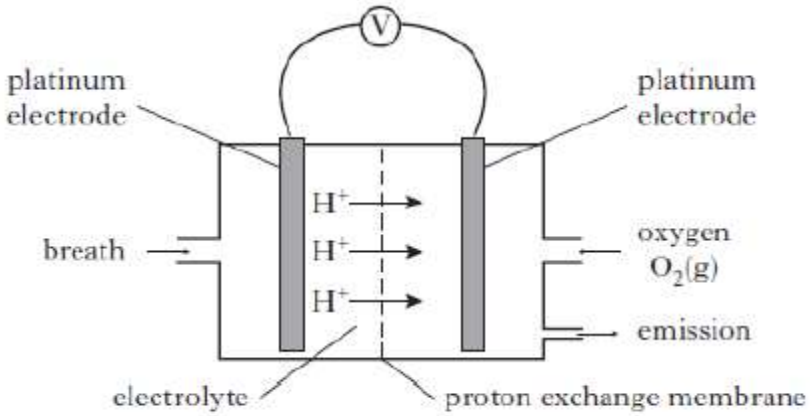
(ii) During the reaction the nitrite ion is oxidised to the nitrate ion.

Complete the ion-electron equation for the oxidation of the nitrite ions.

$$NO_2^-(aq) \quad \rightarrow \quad NO_3^-(aq)$$

29.

The concentration of ethanol in a person's breath can be determined by measuring the voltage produced in an electrochemical cell.



The ion-electron equations for the reduction and oxidation reactions occurring in the cell are shown below.

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

$$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$$

Write the overall redox equation for the reaction taking place.

30.

Compounds containing sulphur occur widely in nature.

Hydrogen sulphide, H_2S, formed by the decomposition of proteins, can cause an unpleasant odour in water supplies.

Chlorine, added to the water, removes the hydrogen sulphide.

The equation for the reaction taking place is

$$4Cl_2(aq) + H_2S(aq) + 4H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 10H^+(aq) + 8Cl^-(aq)$$

An average of 29·4 cm^3 of 0·010 mol l^{-1} chlorine solution was required to react completely with a 50·0 cm^3 sample of water.

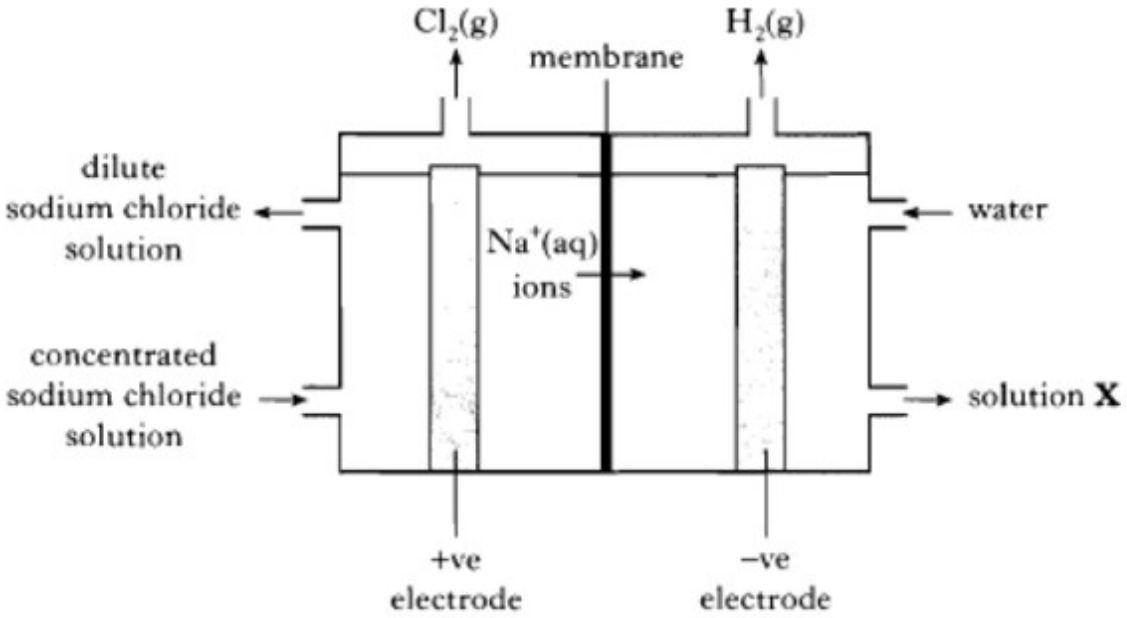
Calculate the hydrogen sulphide concentration, in mol l^{-1}, present in the water sample.

Show your working clearly.

31.

Chlorine can be produced commercially from concentrated sodium chloride solution in a membrane cell.

Only sodium ions can pass through the membrane. These ions move in the direction shown in the diagram.



The reactions at each electrode are:

+ve electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

−ve electrode: $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

Write the overall redox equation for the reaction in the membrane cell.

32.

Silver jewellery discoloured by tarnish (Ag_2S) can be cleaned by placing the item in an aluminium pot containing salt solution. The reaction occurring is shown below.

$$3Ag_2S + 2Al \rightarrow 6Ag + Al_2S_3$$

Which of the following statements is true?

A Aluminium metal is a reducing agent.

B Silver metal is an oxidising agent.

C Silver ions are acting as electron donors.

D Sulfide ions are acting as electron acceptors.

33. Rivers and drains are carefully monitored o ensure that they remain uncontaminated by potentially harmful substances from nearby industries.

Chromate ions, $Cr_2O_4^{2-}$ and nitrite ions, NO_2^- can be detected and concentrations measured.

The concentration of chromate ions in water can be measured by titrating with a solution of iron(II) sulfate solution.

A 50.0cm^3 sample of contaminated water containing chromate ions was titrated with 0.0200 mol l^{-1} sulfate solution.

	Volume of 0.0200 mol l^{-1} iron(II) sulfate solution /cm^3
Titre 1	27.8
Titre 2	27.3
Titre 3	27.5

The redox equation for the reaction is

$$3Fe^{2+}(aq) + CrO_4^-(aq) + 8H^+(aq) \rightarrow 3Fe^{3+}(aq) + Cr^{3+}(aq) + 4H_2O(l)$$

(a) Calculate the chromate ion concentration, in mol l^{-1} present in the sample of water.

(b) The concentration of nitrate ions can be found by titrating 50 cm^3 water samples with acidified potassium permanganate solution

The reaction taking place is

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$$

Describe the colour change that will indicate that the endpoint of the titration has been reached.