9.3 Group properties

01. 0620_m21_qp_42 Q: 2

The elements shown are gases at room temperature and pressure.

hydrogen
nitrogen
oxygen
chlorine

(a) State which **one** of these gases is green.

..... [1]

(b) The gases shown exist as diatomic molecules.

State the name of **another** element which has diatomic molecules and is a gas at room temperature and pressure.

..... [1]

(c) When separate samples of each of these gases are placed in a container they will diffuse.

(i) Describe why these gases diffuse.

..... [1]

(ii) State which of these four gases has the highest rate of diffusion.

Explain your answer.

gas .....

explanation .....

..... [2]

(d) Nitrogen, oxygen and other substances are found in clean, dry air.

(i) State the percentage of nitrogen in clean, dry air.

..... [1]

(ii) Other than nitrogen and oxygen, identify another element found in clean, dry air.

..... [1]

(iii) Identify a compound found in clean, dry air.

..... [1]

(iv) Nitrogen and oxygen can be separated from liquid air.

State the name of this process.

..... [2]

[Total: 10]

02. 0620_m20_qp_42 Q: 3

The Periodic Table is a method of classifying elements.

(a) Identify the element which is in Group VI and Period 4.

..... [1]

(b) Calcium is in Group II and chlorine is in Group VII of the Periodic Table.

Explain, in terms of number of outer shell electrons and electron transfer, how calcium atoms and chlorine atoms form ions. Give the formulae of the ions formed.

.....

.....

.....

.....

.....

.....

..... [5]

(c) Group V chlorides are covalent molecules. The boiling points of some Group V chlorides are shown.

chloride	boiling point/°C
NCl_3	71
PCl_3	
$AsCl_3$	130
$SbCl_3$	283

(i) Suggest the approximate boiling point of PCl_3.

..... [1]

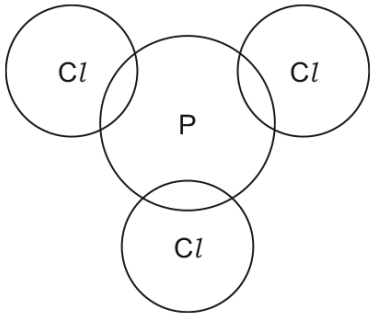
(ii) Explain the trend in boiling points in terms of attractive forces between particles.

.....

..... [2]

(iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of PCl_3.

Show outer electrons only.



[3]

(d) PCl_3 reacts with chlorine, Cl_2, to form PCl_5. This reaction is exhermic and reaches an equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

(i) Describe **two** features of an equilibrium.

.....

.....

..... [2]

(ii) State the effect, if any, on the position of this equilibrium when the following changes are made.
Explain your answers.

temperature is increased .....

.....

pressure is increased .....

.....

[4]

(iii) Explain, in terms of particles, what happens to the rate of the forward reaction when the reaction mixture is heated.

.....

.....

.....

.....

..... [3]

(e) PCl_5 reacts with lithium fluoride, LiF, to form $LiPF_6$.

$$PCl_5 + 6LiF \rightarrow LiPF_6 + 5LiCl$$

Calculate the mass of LiF needed to form 3.04 g of $LiPF_6$ using the following steps.

- Calculate the number of moles of $LiPF_6$ formed.
  [M_r: $LiPF_6$, 152]

number of moles = ...

- Deduce the number of moles of LiF needed.

number of moles = ...

- Calculate the mass of LiF needed.

mass = ... g
[3]

(f) Lithium fluoride has ionic bonding.

(i) What is an ionic bond?

.....

..... [2]

(ii) Give **two** physical properties of ionic compounds.

.....

..... [2]

[Total: 28]

---

03. 0620_s20_qp_43 Q: 3
Chlorine is in Group VII of the Periodic Table.

(a) Two isotopes of chlorine are chlorine-35 and chlorine-37.

(i) State why these two isotopes of chlorine have the same chemical properties.

.....

.....

..... [2]

(ii) Complete the table to show the number of electrons, neutrons and protons in each atom and ion.

	number of electrons	number of neutrons	number of protons
$^{35}_{17}Cl$			
$^{37}_{17}Cl^-$			

[3]

(b) (i) Chlorine reacts with aqueous sodium bromide.

The equation for the reaction is shown.

$$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$$

State the type of reaction shown.

..... [1]

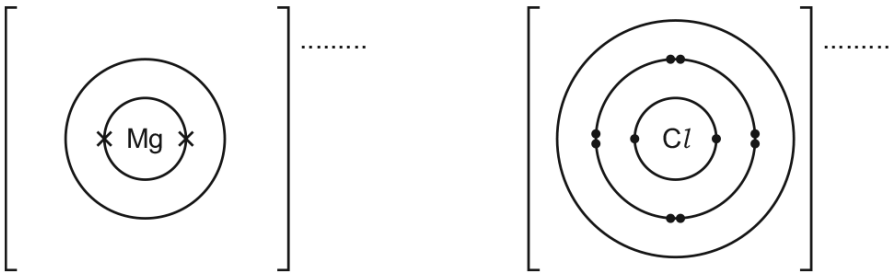
(ii) Why is there **no** reaction between iodine and aqueous sodium bromide?

..... [1]

(c) Magnesium reacts with chlorine to form magnesium chloride.

Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium chloride. Give the charges on the ions.

The inner shells have been completed.



[3]

(d) Hydrogen and chlorine react to form hydrogen chloride gas, as shown in the equation.

$$H_2 + Cl_2 \rightarrow 2HCl$$

This equation can be represented as shown.

$$H–H + Cl–Cl \rightarrow 2H–Cl$$

Some bond energies are shown in the table.

bond	bond energy in kJ/mol
H–H	436
Cl–Cl	243
H–Cl	432

Calculate the energy change for the reaction between hydrogen and chlorine, using the following steps.

- Calculate the energy needed to break the bonds.

..... kJ

- Calculate the energy released when bonds are formed.

..... kJ

- Calculate the energy change for the reaction.

..... kJ/mol
[3]

[Total: 13]

04. 0620_s19_qp_42 Q: 6

The halogens are the elements in Group VII of the Periodic Table.

(a) Predict the physical state and colour of astatine at room temperature and pressure.

physical state .....

colour .....

[2]

(b) When chlorine reacts with aqueous potassium bromide a displacement reaction occurs.

(i) Describe the colour change of the solution.

from ..... to .....

[2]

(ii) Write a chemical equation for this reaction.

..... [2]

(c) Reactions occur when some aqueous solutions of halogens are added to aqueous solutions of halides.

Use the key to complete the table to show the results of adding halogens to halides.

key
✓ = reaction
✗ = no reaction

		halides		
		KC*l*(aq)	KBr(aq)	KI(aq)
halogens	C*l*$_2$(aq)		✓	
	Br$_2$(aq)			
	I$_2$(aq)			

[2]

[Total: 8]

05. 0620_w19_qp_43 Q: 2

The table shows the melting points, boiling points and electrical conductivities of six substances **D**, **E**, **F**, **G**, **H** and **I**.

substance	melting point /°C	boiling point /°C	electrical conductivity when solid	electrical conductivity when liquid
D	1610	2230	non-conductor	non-conductor
E	801	1413	non-conductor	good conductor
F	–119	43	non-conductor	non-conductor
G	1535	2750	good conductor	good conductor
H	114	184	non-conductor	non-conductor
I	–210	–196	non-conductor	non-conductor

Choose substances from the table which match the following descriptions. Each substance may be used once, more than once or not at all.

(a) Which substance is a liquid at 25 °C? ..... [1]

(b) Which substance is a gas at 25 °C? ..... [1]

(c) Which **three** substances contain simple molecules?

..... [3]

(d) Which substance could be a metal? Give a reason for your answer.

substance .....

reason .....

..... [2]

(e) Which substance has a macromolecular structure? Give **two** reasons for your answer.

substance .....

reason 1 .....

reason 2 ..... [3]

(f) Which substance is an ionic solid? Give **one** reason for your answer.

substance .....

reason .....

..... [2]

[Total: 12]

06. 0620_s18_qp_41 Q: 2

Flerovium, Fl, atomic number 114, was first made in research laboratories in 1998.

(a) Flerovium was made by bombarding atoms of plutonium, Pu, atomic number 94, with atoms of element **Z**.

- The nucleus of **one** atom of plutonium combined with the nucleus of **one** atom of element **Z**.
- This formed the nucleus of **one** atom of flerovium.

Suggest the identity of element **Z**.

..... [1]

(b) In which period of the Periodic Table is flerovium?

..... [1]

(c) Predict the number of outer shell electrons in an atom of flerovium.

..... [1]

(d) Two isotopes of flerovium are ^{286}Fl and ^{289}Fl. The nuclei of both of these isotopes are unstable and emit energy when they split up.

(i) State the term used to describe isotopes with unstable nuclei.

..... [1]

(ii) Complete the table to show the number of protons, neutrons and electrons in the atoms of the isotopes shown.

isotope	number of protons	number of neutrons	number of electrons
^{286}Fl			
^{289}Fl			

[2]

(e) Only a relatively small number of atoms of flerovium have been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium is a typical metal.

(i) Suggest **two** physical properties of flerovium.

1 .....

2 .....

[2]

(ii) Suggest **one** chemical property of flerovium oxide.

..... [1]

[Total: 9]

07. 0620_s18_qp_42 Q: 4

Potassium reacts with bromine at room temperature to form potassium bromide.

(a) Write a chemical equation for this reaction. Include state symbols.

..... [3]

(b) Potassium bromide exists as an ionic lattice.
Potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

(i) What is meant by the term *ionic lattice*?

.....

..... [2]

(ii) Explain why potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

.....

.....

..... [2]

(c) Concentrated aqueous potassium bromide is an electrolyte.

(i) What is meant by the term *electrolyte*?

.....

..... [2]

(ii) Describe the electrolysis of concentrated aqueous potassium bromide.

Include:
- an ionic half-equation for the reaction at the cathode
- the name of the product at the anode
- the name of the potassium compound formed.

.....

.....

.....

..... [4]

(iii) When molten potassium bromide is electrolysed, the product at the cathode is different.

Name the product at the cathode when molten potassium bromide is electrolysed.

..... [1]

(d) Iodine reacts with chlorine to form iodine monochloride, IC*l*, as the only product.

(i) Write a chemical equation for this reaction.

..... [2]

(ii) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of iodine monochloride. Show outer shell electrons only.

[2]

(e) Potassium bromide has a melting point of 734 °C.
Iodine monochloride has a melting point of 27 °C.

In terms of attractive forces, explain why there is a large difference between these melting points.

.....

.....

.....

.....

..... [3]

(f) When chlorine gas is passed through aqueous potassium bromide, a redox reaction occurs. The ionic equation is shown.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

(i) Write an ionic half-equation showing what happens to the chlorine molecules, Cl_2, in this reaction.

..... [1]

(ii) Explain why the bromide ions, Br^-, act as reducing agents in this reaction.

..... [1]

[Total: 23]

08. 0620_w18_qp_41 Q: 2

The table gives some information about four different particles, **A**, **B**, **C** and **D**.

particle	number of electrons	number of neutrons	number of protons	electronic structure	charge on particle
A	11	12	11	2,8,1	0
B		14	11	2,8,1	0
C	18	20		2,8,8	0
D	18	20	17		

(a) Complete the table. The first row has been done for you. [4]

(b) Give **two** particles from the table which are isotopes of each other.

..... [1]

(c) Element **Z** is in the same group of the Periodic Table as **A** and is less reactive than **A**.

State the identity of element **Z**.

..... [1]

(d) **C** is unreactive.

Use information from the table to explain why.

..... [1]

[Total: 7]

09. 0620_s17_qp_42 Q: 5

(a) The elements in Group VII are known as the halogens. Some halogens react with aqueous solutions of halides.

(i) Complete the table by adding a ✓ to indicate when a reaction occurs and a ✗ to indicate when no reaction occurs.

	aqueous potassium chloride	aqueous potassium bromide	aqueous potassium iodide
chlorine	✗	✓	
bromine		✗	
iodine			✗

[3]

(ii) Write a chemical equation for the reaction between chlorine and aqueous potassium bromide.

..... [1]

(b) A sample of vanadium chloride was weighed and dissolved in water. An excess of aqueous silver nitrate, acidified with dilute nitric acid, was added. A precipitate of silver chloride was formed. The ionic equation for this reaction is shown.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The mass of silver chloride formed was 2.87 g.

(i) State the colour of the precipitate of silver chloride.

..... [1]

(ii) The relative formula mass of silver chloride, AgCl, is 143.5.

Calculate the number of moles in 2.87 g of AgCl.

moles of AgCl = ... mol [1]

(iii) Use your answer to **(b)(ii)** and the ionic equation to deduce the number of moles of chloride ions, Cl^-, that produced 2.87 g of AgCl.

moles of Cl^- = ... mol [1]

(iv) The amount of vanadium chloride in the sample was 0.01 moles.

Use this and your answer to **(b)(iii)** to deduce the **whole number** ratio of moles of vanadium chloride : moles of chloride ions.
Deduce the formula of vanadium chloride.

moles of vanadium chloride : moles of chloride ions ..... : .....

formula of vanadium chloride .....
[2]

(c) Astatine is at the bottom of Group VII. Use your knowledge of the properties of the halogens to

(i) predict the physical state of astatine at room temperature and pressure,

..... [1]

(ii) write a chemical equation for the reaction between sodium and astatine.

..... [2]

(d) Iodine reacts with chlorine. The chemical equation is shown.

$$I_2 + Cl_2 \rightarrow 2ICl$$

Use the bond energies to answer the questions.

bond	bond energy in kJ/mol
I–I	151
Cl–Cl	242
I–Cl	208

(i) Calculate the total amount of energy required to break the bonds in 1 mole of I_2 and 1 mole of Cl_2.

..... kJ [1]

(ii) Calculate the total amount of energy given out when the bonds in 2 moles of ICl are formed.

..... kJ [1]

(iii) Use your answers to **(d)(i)** and **(d)(ii)** to calculate the overall energy change for the reaction.

$$I_2 + Cl_2 \rightarrow 2ICl$$

..... kJ/mol [1]

[Total: 15]

10. 0620_w17_qp_42 Q: 1

(a) Dust particles in the air move around in a random way.

(i) What term describes the random movement of the dust particles?

..... [1]

(ii) Identify the particles in the air which cause the random movement of the dust particles.

..... [2]

(iii) Explain why the dust particles move in this way.

.....

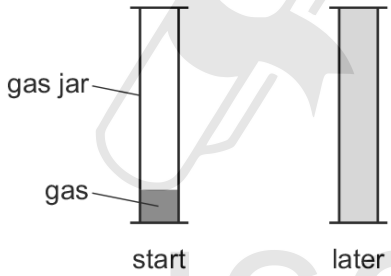
.....

..... [2]

(b) When chlorine gas, Cl_2, is put into a gas jar, it spreads out to fill the gas jar.

When bromine gas, Br_2, is put into a gas jar, it also spreads out to fill the gas jar.

The process takes longer for bromine gas than for chlorine gas.



(i) What term describes the way that the gas particles spread out?

..... [1]

(ii) Use **data** from the Periodic Table to explain why bromine gas takes longer to fill a gas jar than chlorine gas.

.....

.....

..... [2]

(iii) Explain why increasing the temperature increases the rate at which the gas particles spread out.

.....

..... [1]

[Total: 9]

11. 0620_p16_qp_40 Q: 1

The following table gives information about six substances.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	–188	–42	poor	poor
C	776	1497	poor	good
D	–117	78	poor	poor
E	1607	2227	poor	poor
F	–5	102	poor	good

(a) Which substance could be a metal?

..... [1]

(b) State **all** the substances that are liquid at room temperature?

..... [1]

(c) Which substance could have a macromolecular structure similar to that of silicon(IV) oxide?

..... [1]

(d) Which substance could be propane?

..... [1]

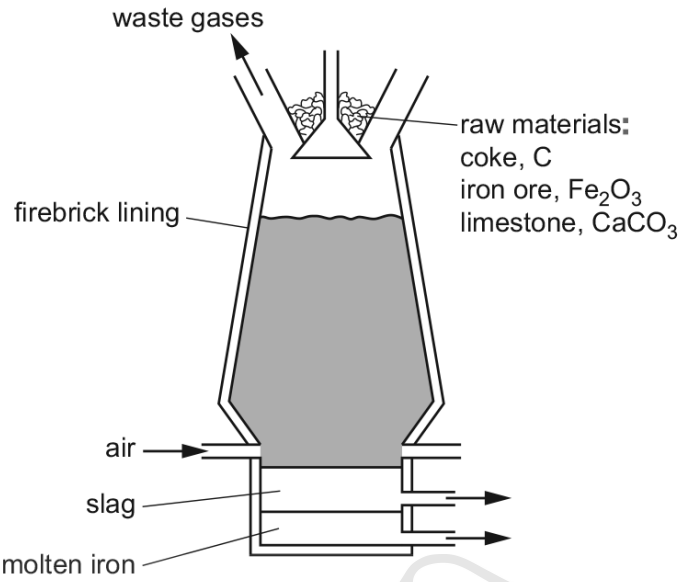
(e) Which substance could be sodium chloride?

..... [1]

[Total: 5]

12. 0620_p16_qp_40 Q: 5

Iron is extracted from its ore, hematite, in the blast furnace.



Describe the reactions involved in this extraction.

Include one equation for a redox reaction and one for an acid/base reaction.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 5]

13. 0620_s15_qp_31 Q: 5

The halogens are a group of non-metals in Group VII of the Periodic Table.

(a) The reactivity of the halogens decreases down the group.

Describe an experiment which shows that chlorine is more reactive than iodine. Include an equation in your answer.

.....

.....

.....

..... [3]

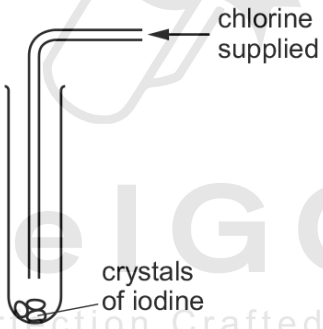
(b) The halogens form interhalogen compounds. These are compounds which contain two different halogens.

Deduce the formula of the compound which has the composition 0.013 moles of iodine atoms and 0.065 moles of fluorine atoms.

.....

..... [2]

(c) Iodine reacts with chlorine to form a dark brown liquid, iodine monochloride.



$$I_2(s) + Cl_2(g) \rightarrow \underset{\text{dark brown}}{2ICl(l)}$$

When more chlorine is added and the tube is sealed, a reversible reaction occurs and the reaction comes to equilibrium.

$$\underset{\text{dark brown}}{ICl(l)} + Cl_2(g) \rightleftharpoons \underset{\text{yellow}}{ICl_3(s)}$$

(i) Give another example of a reversible reaction.

..... [1]

(ii) Explain the term *equilibrium*.

.....

..... [2]

(d) Chlorine is removed from the tube and a new equilibrium is formed.

Explain why there is less of the yellow solid and more dark brown liquid in the new equilibrium mixture.

.....

.....

..... [2]

(e) A sealed tube containing the equilibrium mixture is placed in ice-cold water. There is an increase in the amount of yellow solid in the equilibrium mixture.

What can you deduce about the forward reaction in this equilibrium?

$$ICl(l) + Cl_2(g) \rightleftharpoons ICl_3(s)$$

Explain your deduction.

.....

.....

.....

..... [3]

[Total: 13]

14. 0620_w15_qp_32 Q: 1

Use your copy of the Periodic Table to help you answer some of these questions.

(a) Predict the formulae of the following compounds.

(i) nitrogen fluoride .....

(ii) phosphorus sulfide .....

[2]

(b) Deduce the formulae of the following ions.

(i) selenide .....

(ii) gallium .....

[2]

(c) Use the following ions to determine the formulae of the compounds.

ions OH^- Cr^{3+} Ba^{2+} SO_4^{2-}

compounds

(i) chromium(III) sulfate .....

(ii) barium hydroxide .....

[2]

[Total: 6]

15. 0620_w15_qp_32 Q: 6

The table below shows the elements in the third period of the Periodic Table, the number of electrons in their outer energy level, their oxidation state in their common compounds and their melting points.

element	Na	Mg	Al	Si	P	S	Cl	Ar
number of outer electrons	1	2	3	4	5	6	7	8
oxidation state	+1	+2	+3	+4/–4	–3	–2	–1	0
melting point/°C	98	650	660	1414	317	115	–101	–189

(a) Describe and explain the variation in oxidation state across the period.

.....

.....

..... [3]

(b) The first three elements, Na, Mg and Al, are metals.

Describe the structure of a typical metal.

.....

.....

..... [3]

(c) Explain why Na, Mg and Al are good conductors of electricity.

..... [1]

(d) Which element exists as diatomic molecules of the type X_2?

..... [1]

(e) Silicon has a similar structure to diamond.

Explain why silicon has the highest melting point in the period.

.....

..... [2]

(f) Sodium chloride is a crystalline solid with a high melting point. It dissolves in water to give a neutral solution. Phosphorus trichloride is a liquid at room temperature. It reacts with water to form an acidic solution.

Suggest an explanation for these differences in properties.

.....

.....

..... [2]

(g) Describe how you could show that magnesium oxide is a basic oxide and not an amphoteric oxide.

.....

..... [2]

(h) Draw a dot-and-cross diagram showing the bonding in magnesium oxide. Show outer electrons only.

[3]

[Total: 17]

16. 0620_s14_qp_32 Q: 1

The table below gives the electron distributions of atoms of different elements.

element	electron distribution
A	2 + 7
B	2 + 8 + 4
C	2 + 8 + 8 + 1
D	2 + 8 + 18 + 5
E	2 + 8 + 18 + 7
F	2 + 8 + 18 + 18 + 8

For each of the following, select an element or elements from the table that matches the description. Each element may be selected once, more than once or not at all.

(a) These **two** elements are in the same group.

..... [1]

(b) This element forms a fluoride with a formula of the type XF_3.

..... [1]

(c) This element reacts violently with cold water.

..... [1]

(d) This element has a macromolecular structure similar to that of diamond.

..... [1]

(e) The only oxidation state of this element is 0.

..... [1]

(f) This element is bromine.

..... [1]

(g) This element is a good conductor of electricity.

..... [1]

[Total: 7]

17. 0620_w14_qp_33 Q: 1

For each of the following elements give **one** physical property and **one** chemical property.

(a) bromine (Br_2)

physical property .....

chemical property .....

[2]

(b) carbon$_{graphite}$(C)

physical property .....

chemical property .....

[2]

(c) manganese (Mn)

physical property .....

chemical property .....

[2]

[Total: 6]

18. 0620_w13_qp_32 Q: 2

The halogens are a collection of diatomic non-metals in Group VII.

(a) (i) Define the term *diatomic*.

..... [1]

(ii) What do the electron distributions of the halogens have in common?

..... [1]

(iii) How do their electron distributions differ?

..... [1]

(iv) Complete the table.

halogen	solid, liquid or gas at room temperature	colour
chlorine	.....	.....
bromine	.....	.....
iodine	.....	.....

[2]

(b) The halogens react with other non-metals to form covalent compounds.
Draw a diagram which shows the arrangement of the valency electrons in one molecule of the covalent compound arsenic trifluoride.
The electron distribution of an arsenic atom is 2 + 8 + 18 + 5.

Use x to represent an electron from an arsenic atom.
Use o to represent an electron from a fluorine atom.

[3]

(c) Photochromic glass is used in sunglasses. In bright light, the glass darkens reducing the amount of light reaching the eye. When the light is less bright, the glass becomes colourless increasing the amount of light reaching the eye.

Photochromic glass contains very small amounts of the halides silver(I) chloride and copper(I) chloride.
The reaction between these two chlorides is photochemical.

$$\underset{\text{colourless}}{AgCl} + \underset{\text{colourless}}{CuCl} \rightleftharpoons \underset{\text{black}}{Ag} + \underset{\text{colourless}}{CuCl_2}$$

How does photochromic glass work?

.....

.....

..... [3]

[Total: 11]

19. 0620_s12_qp_31 Q: 3

The Group I metals show trends in both their physical and chemical properties.

(a) (i) How do their melting points vary down the Group?

..... [1]

(ii) Which element in the Group has the highest density?

..... [1]

(iii) All Group I metals react with cold water. Complete the following equation.

.....Rb + ...H_2O → ..... + ...

[2]

(b) Lithium reacts with nitrogen to form the ionic compound, lithium nitride.

(i) State the formula of the lithium ion. ..... [1]

(ii) Deduce the formula of the nitride ion. ..... [1]

(iii) In all solid ionic compounds, the ions are held together in a lattice.
Explain the term *lattice*.

.....

..... [1]

(iv) What is the ratio of lithium ions to nitride ions in the lattice of lithium nitride?
Give a reason for your answer.

..... lithium ions : ..... nitride ions

.....

..... [2]

[Total: 9]

20. 0620_w12_qp_31 Q: 2

Three of the halogens in Group VII are listed below.

chlorine
bromine
iodine

(a) (i) How does their colour change down the Group?

..... [1]

(ii) How do their melting points and boiling points change down the Group?

..... [1]

(iii) Predict the colour and physical state (solid, liquid or gas) of astatine, At.

colour .....

physical state ..... [2]

(b) A radioactive isotope of iodine, $^{131}_{53}I$, is used to treat cancer.

(i) Define the term *isotope*.

.....

..... [2]

(ii) How many protons, electrons and neutrons are there in one atom of $^{131}_{53}I$?

number of protons .....

number of electrons .....

number of neutrons ..... [2]

(iii) When this isotope, $^{131}_{53}I$, emits radiation, a different element with a proton number of 54 is formed.
What is the name of this element?

..... [1]

(c) Fluorine, the most reactive halogen, forms compounds with the other halogens. It forms two compounds with bromine.
Deduce their formulae from the following information.

compound 1
The mass of one mole of this compound is 137 g.

Its formula is ..... [1]

compound 2
0.02 moles of this compound contain 0.02 moles of bromine atoms and 0.1 moles of fluorine atoms.

Its formula is ..... [1]

[Total: 11]

01. 0620_m21_ms_42 Q: 2

Question	Answer	Marks
(a)	chlorine	1
(b)	fluorine	1
(c)(i)	random motion of **molecules / particles**	1
(c)(ii)	hydrogen lowest (relative) molecular mass	2
(d)(i)	78	1

Question	Answer	Marks
(d)(ii)	argon / Ar	1
(d)(iii)	carbon dioxide	1
(d)(iv)	fractional (1) distillation (1)	2

02. 0620_m20_ms_42 Q: 3

(a)	selenium / Se	1
(b)	Ca has 2 and C*l* has outer electrons 7 (1) Ca (atoms) lose electrons (1) C*l* (atoms) gain electrons (1) Ca^{2+} (ions) (1) Cl^- (ions) (1)	5

(c)(i)	any number in the range 72 – 129°C	**1**
(c)(ii)	attraction increase (1) between molecules (1)	**2**
(c)(iii)	3 P – C*l* dot cross bonds (1) 2 (only) non-bonding electrons to make an octet on P (1) 6 (only) non-bonding electrons to make an octet on each C*l* (1)	**3**
(d)(i)	constant concentrations (1) rate of forward reaction = rate of reverse reaction (1)	**2**
(d)(ii)	*increased temperature*: (equilibrium) shifts to LHS (1) (forward) reaction is exothermic (1) *increased pressure*: (equilibrium) shifts to RHS (1) fewer moles (of gas) on RHS (1)	**4**
(d)(iii)	rate increases **and** particles have more energy (1) more collisions (between particles) occur per second / per unit time more (of the) particles / collisions have energy greater than activation energy **or** more (of the) particles / collisions have sufficient energy to react **or** a greater percentage / proportion / fraction of collisions (of particles) are successful	**3**
(e)	mol of $LiPF_6$ = 3.04 / 152 = 0.02(00) (1) mol of LiF = 0.02(00) × 6 = 0.12(0) (1) mass of LiF = 3.12 g (1)	**3**
(f)(i)	oppositely charged ions (ions) are attracted	**2**
(f)(ii)	any two from: *physical constants*: high boiling point / melting point *conductivity*: conduct (electricity) when aqueous or conduct (electricity) when molten *solubility*: soluble in water	**2**

03. 0620_s20_ms_43 Q: 3

(a)(i)	same number of electrons same electronic configuration	**2**
(a)(ii)	<table><tr><th></th><th>number of electrons</th><th>number of neutrons</th><th>number of protons</th></tr><tr><td>$^{35}_{17}Cl$</td><td>17</td><td>18</td><td>17</td></tr><tr><td>$^{37}_{17}Cl^-$</td><td>18</td><td>20</td><td>17</td></tr></table>	**3**
(b)(i)	displacement / redox	**1**

(b)(ii)	iodine is less reactive than bromine	**1**
(c)	magnesium ion has an outer shell with eight crosses chloride ion has an outer shell with seven dots **and** one cross chloride has a charge of 1– **and** magnesium has a charge 2+	**3**
(d)	energy needed to break bonds = 436 + 243 = 679 energy released when bonds formed = 2 × 432 = 864 energy change = 679 – 864 = – **AND** 185	**3**

04. 0620_s19_ms_42 Q: 6

(a)	**M1** solid (1) **M2** black (1)	**2**
(b)(i)	**M1** colourless (1) **M2** to brown / orange / yellow (1)	**2**
(b)(ii)	$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ **OR** $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ **M1** all formulae (1) **M2** equation balanced correctly (1)	**2**
(c)	**M1** two ticks for Cl_2 / KI, Br_2 / KI (1) **M2** three crosses for Br_2 / KCl, I_2 / KCl and I_2 / KBr (1)	**2**

05. 0620_w19_ms_43 Q: 2

(a)	F	**1**
(b)	I	**1**
(c)	F (1) H (1) I (1)	**3**
(d)	G (1) good conductor when solid (1)	**2**
(e)	D (1) high melting point (1) non-conductor of electricity when solid or liquid (1)	**3**
(f)	E (1) only conducts when liquid / conducts when liquid but not when solid (1)	**2**

06. 0620_s18_ms_41 Q: 2

(a)	calcium / Ca	**1**
(b)	7	**1**
(c)	4	**1**
(d)(i)	radioisotopes	**1**
(d)(ii)	^{286}Fl 114p 172n 114e	**1**
	^{289}Fl 114p 175n 114e	**1**
(e)(i)	any **two** from: high melting point / boiling point hard dense conduct electricity conduct heat ductile / malleable sonorous lustrous / shiny	**2**
(e)(ii)	basic (oxide)	**1**

07. 0620_s18_ms_42 Q: 4

(a)	$2K(s) + Br_2(l) \rightarrow 2KBr(s)$ 1 mark for formulae all correct 1 mark for balancing 1 mark for state symbols	3
(b)(i)	(ionic): made of, positive and negative ions / anions and cations / oppositely charged ions / unlike charged ions / different charged ions	1
	(lattice): regular / sequence / pattern / alternating / repeated / framework / ordered / organised / network / uniform	1
(b)(ii)	(in solid) ions don't move	1
	(when molten) ions move / ions mobile	1

(c)(i)	substance that conducts electricity / (undergoes) electrolysis	1
	decomposed / chemically changed **OR** molten or liquid or solution or aqueous **AND** containing ions/or ionic	1
(c)(ii)	$2H^+ + 2e(^-) \rightarrow H_2$ 1 mark for $H^+ + e(^-)$ as the only species on the left 1 mark for equation fully correct 1 mark for bromine at the anode 1 mark for potassium hydroxide	4
(c)(iii)	potassium	1
(d)(i)	$I_2 + Cl_2 \rightarrow 2ICl$ 1 mark for formulae all correct 1 mark for correct balancing	2
(d)(ii)	one bonding pair	1
	6 non-bonding electrons on each atom	1
(e)	(potassium bromide): ionic bonds / attraction between ions	1
	(iodine monochloride): intermolecular forces / forces between molecules / named intermolecular forces, e.g. van der Waals / London forces / dispersion forces / dipole- dipole	1
	bonds in KBr are stronger / need more energy to break bonds / ORA	1
(f)(i)	$Cl_2 + 2e(^-) \rightarrow 2Cl^-$	1
(f)(ii)	(bromide ions) lose electrons / donate electrons / are oxidised	1

08. 0620_w18_ms_41 Q: 2

(a)	**M1** 11 **M2** 18 **M3** 2.8.8 **M4** –1	4
(b)	A **and** B	1
(c)	Li / Lithium	1
(d)	it has a complete **or** full **or** 8 electrons in the outer shell	1

09. 0620_s17_ms_42 Q: 5

(a)(i)	<table><tr><th></th><th>aqueous potassium chloride</th><th>aqueous potassium bromide</th><th>aqueous potassium iodide</th></tr><tr><td>chlorine</td><td></td><td></td><td>✓</td></tr><tr><td>bromine</td><td>×</td><td></td><td>✓</td></tr><tr><td>iodine</td><td>×</td><td>×</td><td></td></tr></table> 5 cells completed correctly = [3] 3 or 4 cells completed correctly = [2] 2 cells completed correctly = [1]	3
(a)(ii)	$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ **OR** $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$	1
(b)(i)	white	1
(b)(ii)	0.02 (mol)	1
(b)(iii)	0.02 (mol)	1
(b)(iv)	1:2	1
	VCl_2	1

(c)(i)	solid	1
(c)(ii)	$2Na + At_2 \rightarrow 2NaAt$ **M1** formula of NaAt **M2** equation fully correct	2
(d)(i)	393 (kJ)	1
(d)(ii)	416 (kJ)	1
(d)(iii)	–23 (kJ / mol)	1

10. 0620_w17_ms_42 Q: 1

(a)(i)	Brownian (motion)	1
(a)(ii)	molecules	1
	nitrogen / N_2 / N **OR** oxygen / O_2 / O	1
(a)(iii)	nitrogen **OR** oxygen (particles) collide with / bombard / hit the dust (particles)	1
	(the bombarding particles) move **randomly**	1
(b)(i)	diffusion	1
(b)(ii)	Br_2 has an M_r of 160 **AND** Cl_2 has an M_r of 71 / bromine has an A_r of 80 **AND** chlorine has an A_r of 35.5	1
	(heavier) bromine (molecules / particles) diffuses more slowly	1
(b)(iii)	particles have more energy / move faster	1

11. 0620_p16_ms_40 Q: 1

(a) A [1]

(b) D and F note: both needed for mark [1]

(c) E [1]

(d) B [1]

(e) C [1]

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12. 0620_p16_ms_40 Q: 5

one redox equation from: [1]
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$
$C + O_2 \rightarrow CO_2$
$CO_2 + C \rightarrow 2CO$

one acid/base equation: [1]
$CaO + SiO_2 \rightarrow CaSiO_3$
$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$

Any three additional equations or comments from: [3]
carbon burns or reacts to form carbon dioxide;
this reaction is exothermic or produces heat;
carbon dioxide is reduced to carbon monoxide;
carbon monoxide reduces hematite to iron;
carbon reduces hematite to iron;
limestone removes silica to form slag;
limestone decomposes;

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13. 0620_s15_ms_31 Q: 5

(b)	M1 (0.013 moles of I and 0.065 moles of F atoms gives a) ratio 1:5; Formula = IF_5 ;	2	Award 2 marks for IF_5 **A** one mark for I_5F (as ratio is inverted) **A** one mark for IFl_5 or I_5Fl

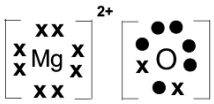
(c)(i)	example of a reversible reaction including attempts at removing / adding waters of crystallisation **OR** example of a reaction which under closed conditions would be reversible;	**1**	**A** written description of the reaction e.g. 'Haber process' unless equation is attempted in which case ignore written description **A** word equations / unbalanced equations **A** equations without equilibrium arrows **I** descriptions of physical changes
(c)(ii)	*Any **two** from:* (a reaction) M1 which can take place in both directions **OR** which can be approached from both directions; M2 in which concentrations / macroscopic properties do not change (with time); M3 the two reaction rates are equal;	 **2**	**I** reference to 'closed system' **A** 'a reaction which can go forwards and backwards' for M1 **I** 'a reaction with an equilibrium arrow' or with '⇌' for M1 **R** concentrations (of reactants and products) are the same
(d)	M1 equilibrium goes to LHS **OR** equilibrium goes to reactants side; M2 because the concentration of chlorine decreases;	 **2**	**A** reaction goes to LHS but **R** 'equilibrium goes to LHS and to products side' **A** backward reaction is favoured **I** less yield or less products **A** 'reactant' for 'chlorine' but not reactants **A** to replace missing chlorine
(e)	M1 equilibrium goes to RHS **OR** equilibrium goes to products side; M2 exothermic reactions are favoured by low temperatures; M3 the forward reaction is exothermic;	 **3**	**A** reaction goes to RHS but **R** 'equilibrium goes to RHS and to reactants side' **A** forward reaction is favoured **I** more yield or more products **A** for M1 and M2 'decreasing temperature makes the equilibrium go to RHS' **A** backward reaction is endothermic

14. 0620_w15_ms_32 Q: 1

(a)(i)	NF_3;	**1**
(a)(ii)	P_2S_3;	**1**
(b)(i)	Se^{2-};	**1**
(b)(ii)	Ga^{3+};	**1**
(c)(i)	$Cr_2(SO_4)_3$;	**1**
(c)(ii)	$Ba(OH)_2$;	**1**

15. 0620_w15_ms_32 Q: 6

(a)	the number of e^- gained or lost = numerical value of oxidation state; any two from: • Na to A*l* (Si) lose e^-; • (Si) P to C*l* gain e^-; • Si gains and loses e^- / Ar neither gains nor loses e^-;	**1** **2**
(b)	**M1** positive ions / cations / metallic ions; the (correct) particles named in **M1** are arranged in a lattice / rows / layers; sea of electrons / delocalised electrons;	**3**
(c)	they have mobile electrons;	**1**
(d)	chlorine;	**1**
(e)	strong covalent bonds ; in a giant lattice / macromolecule / giant (structure);	**2**

(f)	any two from: • sodium chloride is ionic **and** PCl_3 is covalent; • ionic bonds are strong **and** intermolecular forces are weak; • PCl_3 reacts with water **and** NaCl does not;	**2**
(g)	MgO will react with / dissolve in / neutralise hydrochloric acid / acid / acid oxide; if amphoteric, MgO will react with or dissolve in or neutralise hydrochloric acid or acid or acid oxide **and** MgO will react with dissolve in or neutralise sodium hydroxide or alkali or base or basic oxide; MgO will not react with or dissolve in or neutralise sodium hydroxide or alkali or base or basic oxide = [2]	**2**
(h)	 magnesium with 8 or 0 outer shell electrons; oxygen with 8 outer shell electrons and 2 indicated differently from the other 6 and these 2 electrons must match the Mg electrons if these have been shown; correct charges;	**3**

16. 0620_s14_ms_32 Q: 1

(a) A and E **need both** (1) [1]

(b) D (1) [1]

(c) C (1) [1]

(d) B (1) [1]

(e) F (1) [1]

(f) E (1) [1]

(g) C (1) [1]

[Total: 7]

17. 0620_w14_ms_33 Q: 1

(a) Bromine

Physical: reddish-brown liquid **or** brown liquid **or** volatile liquid/low boiling point liquid **or** poor/non-conductor (of electricity) **or** soluble in water **or** soluble in organic/non-polar solvents [1]

Chemical: Reacts with water **or** reacts with iodides (in solution) **or** displaces iodine **or** reacts with alkenes/named alkene/unsaturated hydrocarbons **or** reacts with alkane in UV/named alkane in UV **or** valency/oxidation state(–)1 **or** forms Br^- **or** gains or shares 1 electron **or** combines or reacts with metals/named metal **or** combines or reacts with non-metals/named non-metal **or** oxidising agent **or** bleaches litmus paper/indicator paper **or** corrosive **or** forms acidic oxides [1]

(b) Graphite

Physical: (good) conductor (of electricity) **or** soft **or** lubricant **or** high melting point/high boiling point **or** grey black **or** black solid **or** slippery or greasy (to touch) **or** brittle/breaks when subjected to stress **or** insoluble in water [1]

Chemical: reducing agent **or** reduces metal oxides/named metal oxide **or** reacts with/burns in air/oxygen **or** forms an acidic oxide (CO_2) **or** valency/oxidation state of 2 or 4 [1]

(c) Manganese

Physical: (good) conductor (of heat/electricity) **or** high melting point/high boiling point **or** forms coloured compounds/coloured ions **or** hard **or** strong **or** high density **or** malleable **or** ductile **or** sonorous **or** shiny [1]

Chemical: Variable or different valency/oxidation state/oxidation number **or** catalytic activity **or** forms coloured compounds/coloured ions **or** forms complex ions/complexes **or** reacts with acids **or** reducing agent **or** reacts with non-metals [1]

[Total: 6]

18. 0620_w13_ms_32 Q: 2

(a) (i) two atoms per molecule [1]

(ii) 7e in outer shell or level / same number of outer electrons / need to gain one electron [1]

(iii) different number of energy levels / different number of electrons [1]

(iv)

halogen	solid, liquid or gas at room temperature	colour
chlorine	gas	yellow / yellow green / green
bromine	liquid	brown / red-brown / orange-brown not: red / orange
iodine	solid	black / grey / silver-grey / purple / violet **NOT**: blue-black

NOTE: one mark for each vertical column [2]

(b) correct formula, AsF_3 [1]
3nbps and 1bp around all 3 fluorine atoms [1]
3bps and 1nbp around arsenic atom [1]

(c) (increased) light increases / causes forward reaction / light causes
AgCl reacts with CuCl [1]
(increased) light increases the amount of silver (and so darkens glass) [1]
decrease in light reverses reaction / uses up silver / silver reacts (and so reduces darkness)[1]

[Total: 11]

19. 0620_s12_ms_31 Q: 3

(a) (i) decrease down group; [1]

(ii) caesium / francium; [1]

(iii) $2Rb + 2H_2O \rightarrow 2RbOH + H_2$ [2]
not balanced = [1]

(b) (i) Li^+ [1]

(ii) N^{3-} [1]

(iii) regular arrangement of ions / particles / positive and negative ions alternate; [1]
not: atoms

(iv) 3:1; [1]
ratio to balance charges / reason in terms of valency; [1]

[Total: 9]

(a) **(i)** become darker; [1]

(ii) increase; [1]

(iii) black / dark grey; [1]
not: brown
solid; [1]

(b) **(i)** same Z / same number of protons; [1]
accept: atoms of the same element
different number of neutrons / different nucleon number / different mass number; [1]

(ii) 53 protons and 53 electrons; [1]

78 neutrons; [1]

(iii) xenon; [1]

(c) BrF_3 / F_3Br; [1]
BrF_5 / F_5Br; [1]

[Total: 11]