Atomic Structure 5

Name: _____

Class: _____

Date: _____

Time: **92 minutes**

Marks: **83 marks**

Comments:

1. This question is about Group 7 elements.

(a) What are the Group 7 elements known as?

_____

(1)

(b) Why do Group 7 elements react in similar ways?

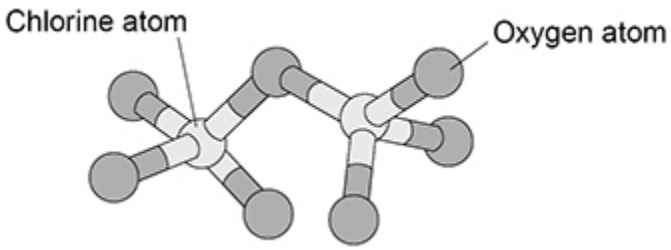
_____

_____

(1)

(c) **Figure 1** shows the structure of a molecule of chlorine oxide.

Figure 1



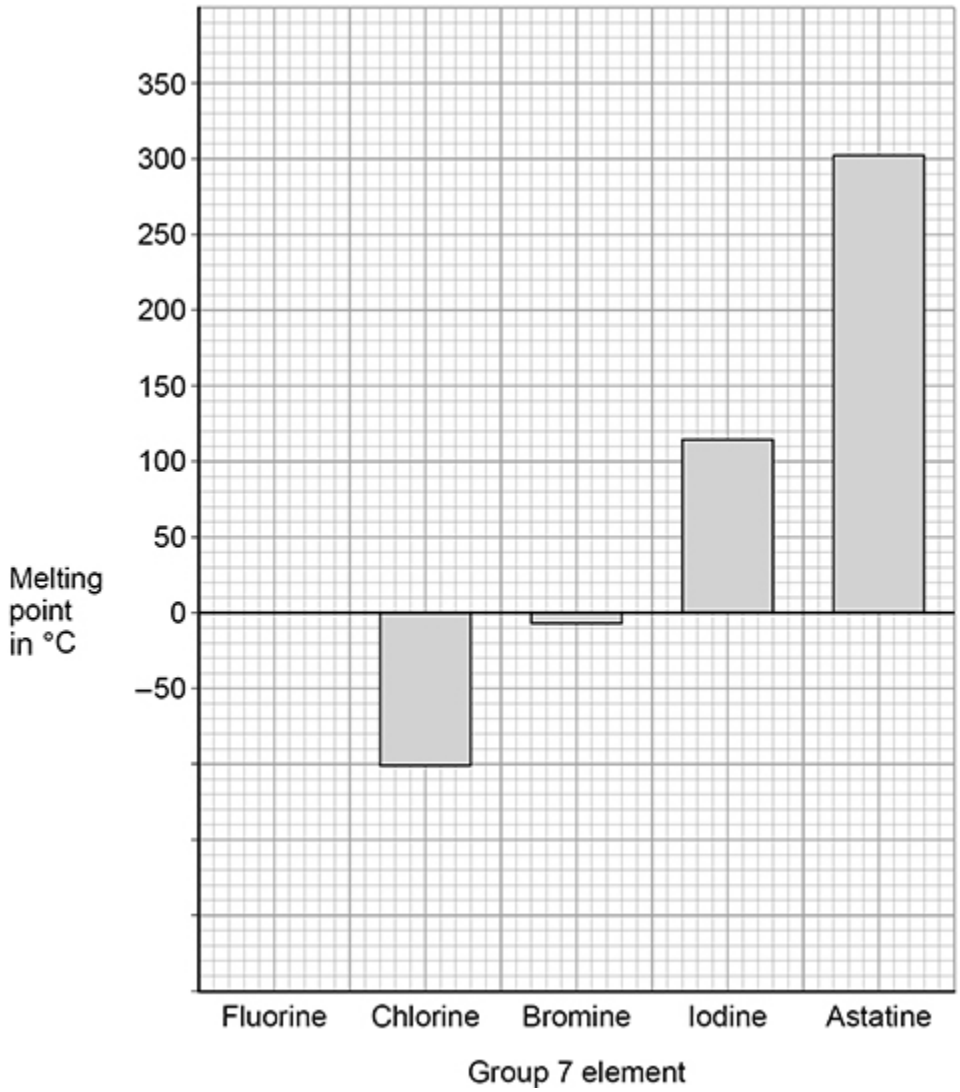
What is the molecular formula of the chlorine oxide molecule in **Figure 1**?

_____

(1)

Figure 2 shows the melting points of some Group 7 elements.

Figure 2



(d) The melting point of fluorine is –220 °C

Complete **Figure 2**.

You should:

- complete the scale on the y-axis
- draw the bar for the melting point of fluorine.

(2)

(e) Explain the trend in the melting points of the Group 7 elements.

Use **Figure 2**.

(3)

(f) What is the state symbol for bromine at –50 °C?

Use **Figure 2**.

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

(1)

(g) Evaporation and boiling occur at the surface of bromine at its boiling point.

Name **one** more process that happens at the surface of bromine at its boiling point.

(1)

(Total 10 marks)

2. Magnesium is in Group 2 of the periodic table.

1.0 g of magnesium reacted with chlorine to produce magnesium chloride.

(a) Which types of element react when magnesium reacted with chlorine?

Tick (✓) **one** box.

A metal and a metal ☐

A metal and a non-metal ☐

A non-metal and a non-metal ☐

(1)

(b) Write the word equation for the reaction when magnesium reacts with chlorine.

_____ + _____ → _____

(1)

(c) What apparatus was used to measure the mass of 1.0 g of magnesium?

Tick (✓) **one** box.

Balance ☐

Beaker ☐

Ruler ☐

(1)

(d) What mass of magnesium chloride was produced?

Tick (✓) **one** box.

Less than 1.0 g ☐

1.0 g ☐

More than 1.0 g ☐

(1)

(e) Magnesium reacts with oxygen to produce magnesium oxide.

Calculate the percentage mass of magnesium in magnesium oxide (MgO).

Relative atomic mass (A_r): Mg = 24

Relative formula mass (M_r): MgO = 40

_____

_____

_____

Percentage mass of magnesium = _____ %

(2)

Magnesium carbonate decomposes to produce magnesium oxide and carbon dioxide.

The word equation for the reaction is:

magnesium carbonate → magnesium oxide + carbon dioxide

Four students heated 2.00 g of magnesium carbonate for 10 minutes.

The table below shows the results.

Mass of carbon dioxide produced in g				
Student 1	**Student 2**	**Student 3**	**Student 4**	**Mean**
0.97	0.91	0.50	0.95	**X**

(f) What is the most likely reason for **Student 3**'s anomalous result?

Tick (✓) **one** box.

The student heated more than 2.00 g of magnesium carbonate. ☐

The student heated the magnesium carbonate for less than 10 minutes. ☐

The student used a higher temperature. ☐

(1)

(g) Calculate value **X** in the table above.

Do **not** use the anomalous result.

Give your answer to 2 significant figures.

_____

_____

_____

_____

X (2 significant figures) = _____ g

(3)

(Total 10 marks)

3. Carbon can exist in a number of different structures.

(a) What is the approximate radius of a carbon atom?

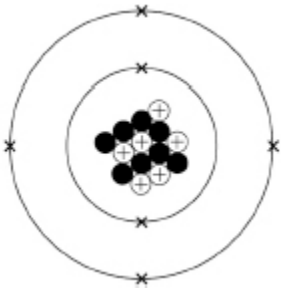
Tick (✓) **one** box.

0.1 m ☐ 0.1 mm ☐ 0.1 nm ☐

(1)

(b) **Figure 1** shows an atom of carbon.

Figure 1



Describe the atomic structure of this carbon atom.

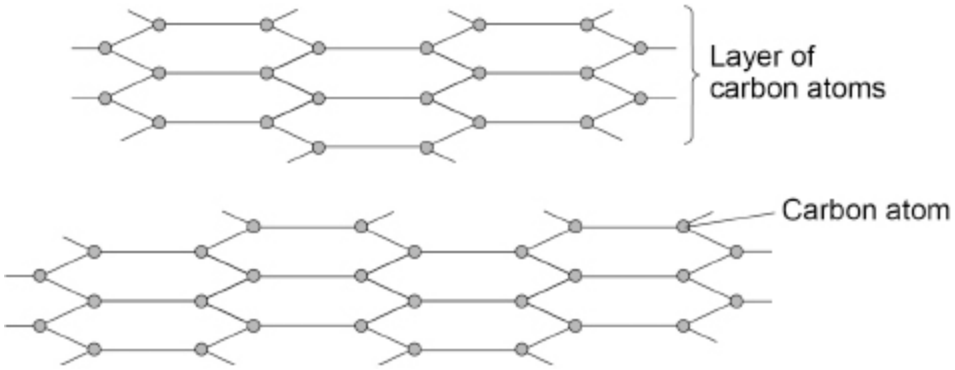
You should include the number of electrons, neutrons and protons.

(6)

In graphite the carbon atoms are held together by bonds.

Figure 2 represents part of the structure of graphite.

Figure 2



(c) How many bonds does each carbon atom have in graphite?

Use **Figure 2**.

Tick (✓) **one** box.

1 ☐ 2 ☐ 3 ☐ 4 ☐

(1)

(d) What type of bonds hold the carbon atoms together in graphite?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

(e) Lubricants allow objects to slide over each other easily.

Suggest why graphite can be used as a lubricant.

Use **Figure 2**.

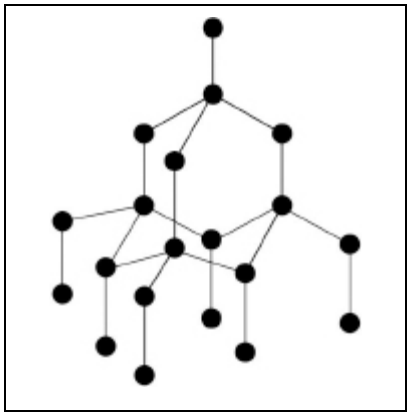
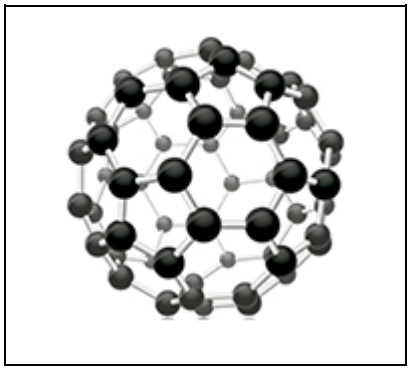
_____

_____

(1)

(f) The two structures represent different forms of carbon.

Draw **one** line from each structure to the form of carbon.

Structure	Form of carbon
	Buckminsterfullerene
	Diamond
	Graphene
	Nanotube

(2)

(Total 12 marks)

4. Sodium and potassium are Group 1 elements.

(a) What is the name of Group 1 elements?

Tick (✓) **one** box.

Alkali metals ☐

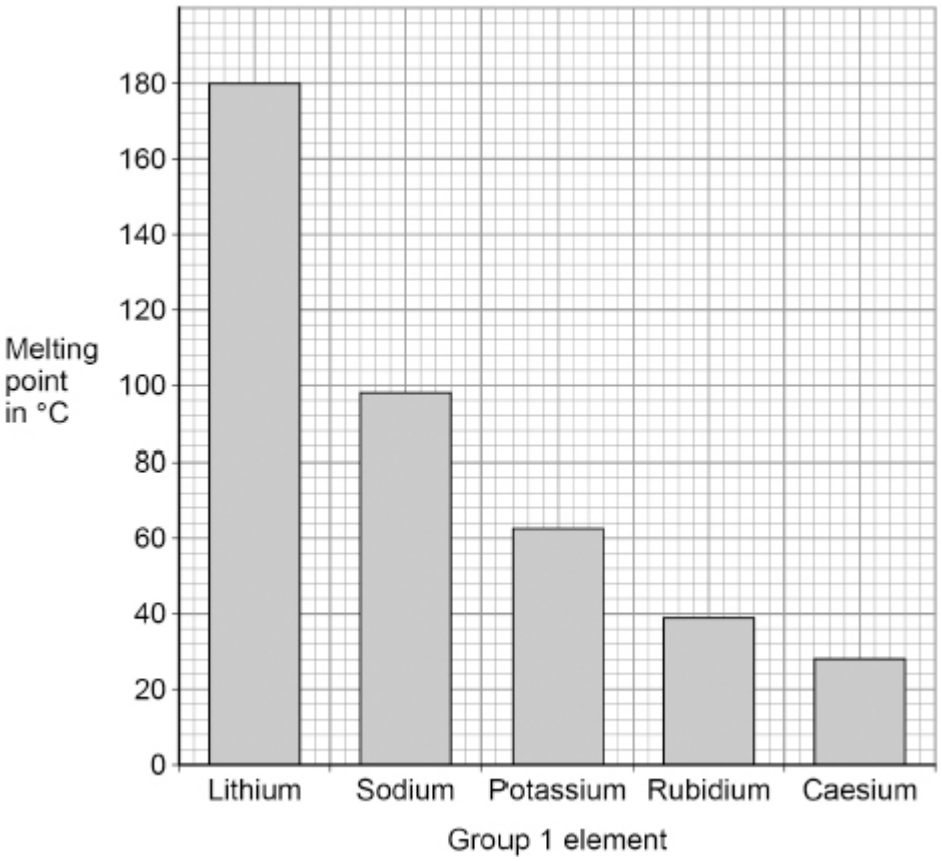
Halogens ☐

Noble gases ☐

(1)

(b) **Figure 1** represents the melting points of Group 1 elements.

Figure 1



What is the melting point of sodium?

Melting point of sodium = _____ °C

(1)

(c) Sodium reacts with water to produce sodium hydroxide and hydrogen.

Balance the equation for the reaction.

$$\_\_\_\_\_\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$$

(1)

(d) Calculate the relative formula mass (M_r) of sodium hydroxide (NaOH).

Relative atomic masses (A_r): H = 1 O = 16 Na = 23

_____

_____

_____

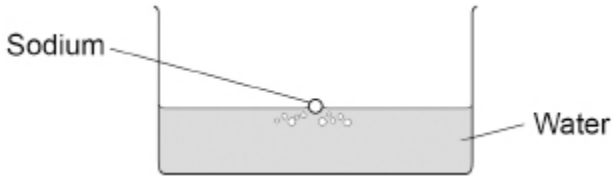
Relative formula mass (M_r) = _____

(2)

(e) Sodium and potassium both react with water.

Figure 2 shows sodium reacting with water.

Figure 2



Compare what is seen when sodium reacts with water and when potassium reacts with water.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

5. This question is about the periodic table.

(a) **Figure 1** shows part of Mendeleev's version of the periodic table.

Figure 1

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn		Ti	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	I	Ru Rh Pd

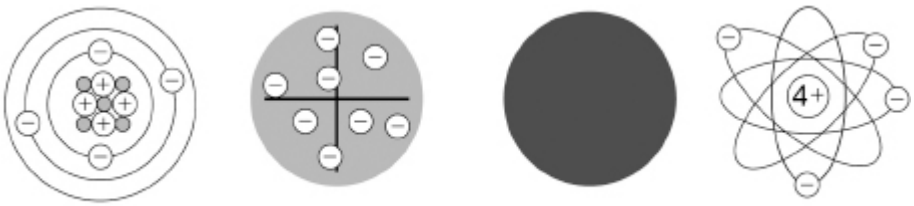
Which group of elements had **not** been discovered when Mendeleev's version of the periodic table was published?

_____

(1)

Figure 2 represents different models of the atom.

Figure 2



A **B** **C** **D**

(b) Which model represents the plum pudding model?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Which model resulted from Chadwick's experimental work?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

Potassium has different isotopes.

(d) What is meant by 'isotopes'?

You should refer to subatomic particles.

_____

_____

_____

_____

(2)

(e) The table below shows the mass numbers and the percentage abundance of two isotopes of potassium.

Mass number	**Percentage abundance**
39	93.1
41	6.9

Calculate the relative atomic mass (A_r) of potassium.

Give your answer to 1 decimal place.

_____

_____

_____

_____

_____

Relative atomic mass (1 decimal place) = _____

(3)

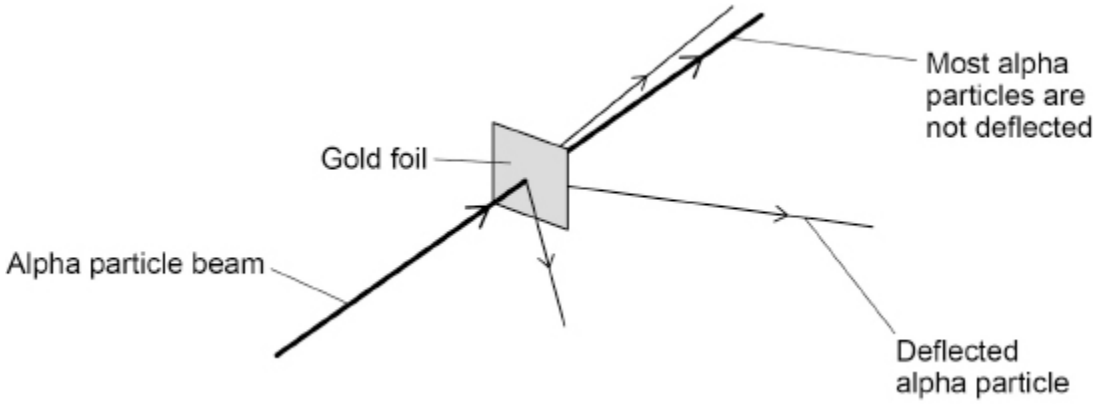
(Total 8 marks)

6. This question is about gold and compounds of gold.

In the alpha particle scattering experiment alpha particles are fired at gold foil.

Alpha particles are positively charged.

The diagram below shows the results.



(a) Some alpha particles are deflected.

Complete the sentence.

Choose the answer from the box.

negatively charged	**not charged**	**positively charged**

Some alpha particles are deflected because the nucleus of the

atom is _____.

(1)

(b) Why are most alpha particles **not** deflected?

Tick (✓) **one** box.

The atom is a tiny sphere that cannot be divided. ☐

The atom is mainly empty space. ☐

The electrons orbit the nucleus at specific distances. ☐

(1)

(c) What was **one** conclusion from the alpha particle scattering experiment?

Tick (✓) **one** box.

The mass is concentrated at the centre of the atom. ☐

The mass is concentrated at the edge of the atom. ☐

The mass is spread evenly throughout the atom. ☐

(1)

Gold reacts with the elements in Group 7 of the periodic table.

(d) What are Group 7 elements known as?

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

Noble gases ☐

(1)

(e) Fluorine, chlorine and bromine react with gold.

Which element will be the most reactive with gold?

Tick (✓) **one** box.

Fluorine ☐ Chlorine ☐ Bromine ☐

(1)

(f) 3.94 g of gold reacts with chlorine to produce 6.07 g of gold chloride.

The word equation for the reaction is:

gold + chlorine → gold chloride

Calculate the mass of chlorine that reacts with 3.94 g of gold.

_____

_____

Mass = _____ g

(1)

(g) Calculate the relative formula mass (M_r) of gold chloride ($AuCl_3$).

Relative atomic masses (A_r): Cl = 35.5 Au = 197

_____

_____

_____

_____

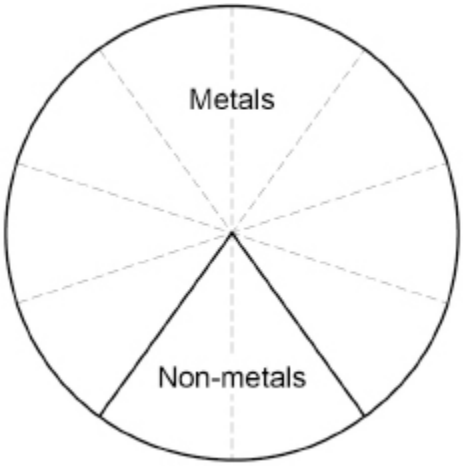
Relative formula mass (M_r) = _____

(2)

(Total 8 marks)

7. This question is about elements and compounds.

(a) The chart below shows the proportion of elements in the periodic table that are metals and non-metals.



Determine the percentage of the elements in the chart above that are metals.

_____

_____

Percentage = _____ %

(2)

(b) Give **two** physical properties of metals.

1. _____

_____

2. _____

_____

(2)

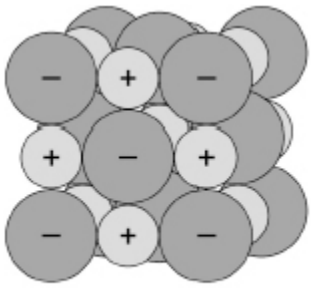
(c) Sodium reacts with chlorine to produce sodium chloride.

Balance the equation for the reaction.

$$\_\_\_\_\_\ Na + Cl_2 \rightarrow \_\_\_\_\_\ NaCl$$

(1)

The diagram below shows part of the structure of sodium chloride (NaCl).



Sodium chloride

(d) What holds the particles together in sodium chloride?

Use the diagram above.

Tick (✓) **one** box.

Electrostatic attractions	☐
Intermolecular forces	☐
Metallic bonds	☐

(1)

(e) Solid sodium chloride does not conduct electricity.

Give **two** ways in which sodium chloride can be made to conduct electricity.

1. _____

_____

2. _____

_____

(2)

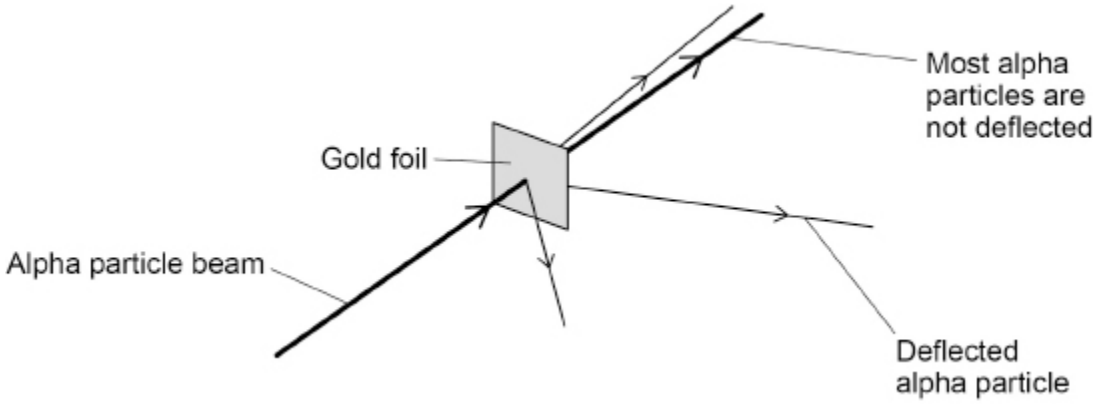
(Total 8 marks)

8. This question is about gold and compounds of gold.

(a) In the alpha particle scattering experiment alpha particles are fired at gold foil.

Alpha particles are positively charged.

The diagram below shows the results.



What **two** conclusions can be made from the results?

Tick (✓) **two** boxes.

Atoms are balls of positive charge with embedded electrons.	☐
Atoms are tiny spheres that cannot be divided.	☐
Atoms have a positively charged nucleus.	☐
Mass is concentrated in the nucleus in the centre of atoms.	☐
Neutrons exist within the nucleus.	☐

(2)

(b) The gold foil is:

- 4.00×10^{-7} metres thick
- 2400 atoms thick.

What is the diameter of one gold atom in metres?

Give your answer to 3 significant figures.

_____

_____

_____

_____

_____

_____

Diameter of one gold atom (3 significant figures) = _____ m

(3)

(c) Gold reacts with the elements in Group 7 of the periodic table.

0.175 g of gold reacts with chlorine.

The equation for the reaction is:

$$2\ Au + 3\ Cl_2 \rightarrow 2\ AuCl_3$$

Calculate the mass of chlorine needed to react with 0.175 g of gold.

Give your answer in mg

Relative atomic masses (A_r): Cl = 35.5 Au = 197

Mass of chlorine = _____ mg

(5)

(Total 10 marks)

9. This question is about the periodic table and argon.

(a) What order did scientists use to arrange elements in early periodic tables?

Tick (✓) **one** box.

- Atomic weight of element ☐
- Number of neutrons in an atom of element ☐
- Size of atoms of element ☐
- Year element was discovered ☐

(1)

(b) In early periodic tables some elements were placed in the wrong groups.

Mendeleev overcame some of these problems in his periodic table.

Complete the sentence.

Mendeleev did this by leaving _____ for elements that had not been discovered.

(1)

(c) What is the name of the group that contains argon?

Tick (✓) **one** box.

- Alkali metals ☐
- Halogens ☐
- Noble gases ☐

(1)

(d) An atom of argon is represented as $^{40}_{18}Ar$

Determine the number of protons and the number of neutrons in one atom of argon.

Number of protons _____

Number of neutrons _____

(2)

(e) Different atoms of argon are, $^{39}_{18}Ar$ and $^{38}_{18}Ar$

What is the name given to these different atoms of argon?

Tick (✓) **one** box.

Fullerenes ☐

Ions ☐

Isotopes ☐

Molecules ☐

(1)

(f) What is the electronic structure of an argon atom, $^{40}_{18}Ar$?

Tick (✓) **one** box.

2 ☐ 2, 8 ☐ 2, 8, 2 ☐ 2, 8, 8 ☐

(1)

(g) Why is argon unreactive?

_____

_____

(1)

(Total 8 marks)

1. (a) halogens

1

(b) all have 7 electrons in outer shell
or
all have 7 outer electrons

allow same number of outer electrons

allow one electron required to complete the outer shell

1

allow energy level for shell

(c) Cl_2O_7

1

(d) *y*-axis scale correct from –100 to –250 °C

1

bar correctly plotted at –220 °C

allow a tolerance of ± ½ a small square

1

(e) (the) molecules increase in size going down the group

allow atoms increase in size going down the group

allow increase in number of electron shells going down group

1

(so the) forces between the molecules increase
or
(so the) intermolecular forces increase

1

(so the) melting points increase going down the group

allow (so) more energy is needed to separate the molecules

or
(so the) melting points increase with increasing relative atomic mass

1

allow converse explanation in terms of decreasing melting point

(f) (s)

1

(g) condensation

allow condensing

ignore evaporating and boiling

1

[10]

2. (a) a metal and a non-metal

1

(b) magnesium + chlorine → magnesium chloride

allow Mg for magnesium

allow Cl_2 for chlorine

allow $MgCl_2$ for magnesium chloride

1

(c) balance

1

(d) more than 1.0 g

1

(e) $(\% =) \frac{24}{40} \times 100$

1

= 60 (%)

1

(f) the student heated the magnesium carbonate for less than ten minutes

1

(g) $\frac{0.97 + 0.91 + 0.95}{3}$ **or** $\frac{2.83}{3}$

1

= 0.943333 (g)

*allow for **1** mark*

$\frac{0.97 + 0.91 + 0.50 + 0.95}{4}$ **or** $\frac{3.33}{4}$

= 0.8325 (g)

1

= 0.94 (g)

allow an answer correctly rounded to 2 significant figures using values from the table

1

[10]

3. (a) 0.1 nm

1

(b) 6 protons

1

8 neutrons

1

6 electrons

allow electron (structure) 2,4

1

protons in nucleus

1

neutrons in nucleus

1

electrons (around nucleus) in energy levels / shells

1

(c) 3

1

(d) covalent

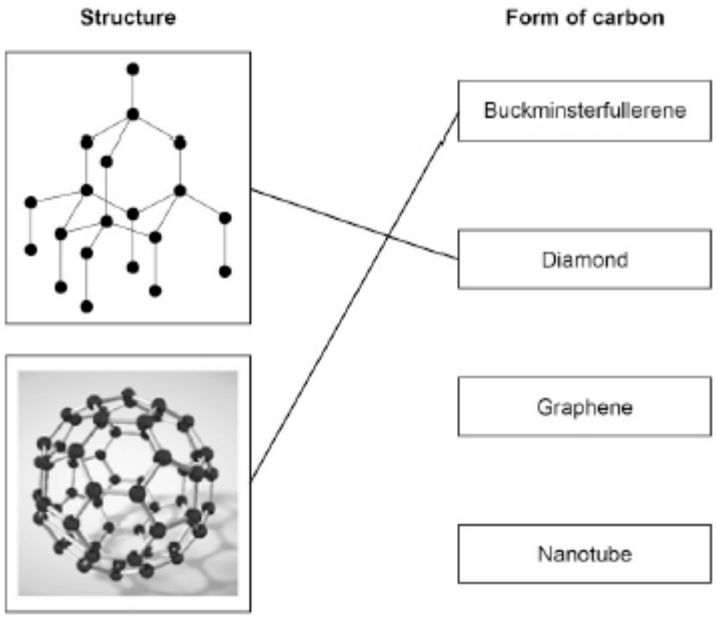
1

(e) layers slide (over each other)

allow atoms slide over each other

1

(f)



do **not** accept more than **one** line from a box on the left

1

1

[12]

4. (a) alkali metals

1

(b) 98 (°C)

allow a <u>value</u> in the range 97–99 (°C)

1

(c) $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

allow multiples

1

(d) (M_r =) 23 + 16 + 1

1

= 40

1

(e) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.

3–4

Level 1: Relevant features are identified and differences noted.

1–2

No relevant content

0

Indicative Content:

<u>Similarities – sodium and potassium both:</u>

- float
- move
- bubble / effervesce / fizz
- melt
- form a ball
- get smaller **or** disappear

<u>Differences – potassium:</u>

- moves faster
- bubbles faster
- reacts faster
- disappears faster
- catches fire
- lilac flame

[9]

5.

(a) (Group) 0
or
noble gases

1

(b) B

1

(c) A

1

(d) (atoms with the) same number of protons

allow atoms with the same atomic number

allow atoms of the same element

ignore the same number of electrons

1

(but with) different numbers of neutrons

ignore (but with) different mass numbers

*do **not** accept (but with) different relative atomic mass*

1

(e) $\frac{(39 \times 93.1) + (41 \times 6.9)}{100}$

1

= 39.138

1

= 39.1

*allow correctly rounded answer to **1** decimal place from an incorrect calculation using all the values given in the question*

1

[8]

6.

(a) positively charged

1

(b) the atom is mainly empty space.

1

(c) the mass is concentrated at the centre of the atom.

1

(d) halogens

1

(e) fluorine

1

(f) 2.13 (g)

1

(g) 197 + (3 × 35.5)
or
197 + 106.5

1

= 303.5

1

[8]

7. (a) $\frac{8}{10} \times 100$ **or** 0.8×100

1

= 80 (%)

*if no other mark awarded allow **1** mark for 20 (%)*

1

(b) any **two** from:

- conducts electricity
- conducts thermal energy

  allow conducts heat
- ductile
- high melting point

  allow high boiling point
- malleable

  allow can be bent / shaped
- shiny
- strong

  allow dense

  allow sonorous

  ignore chemical properties

2

(c) $2\ Na + Cl_2 \rightarrow 2\ NaCl$

allow multiples

1

(d) electrostatic attractions

1

(e) (heat sodium chloride until) molten / liquid

1

dissolve in water

allow form aqueous solution

allow add water

1

[8]

8. (a) atoms have a positively charged nucleus.

1

mass is concentrated in the nucleus in the centre of atoms.

1

(b)

$$\frac{4 \times 10^{-7}}{2400}$$

1

$= 1.66666 \times 10^{-10}$

1

$= 1.67 \times 10^{-10}$ (m)

allow 0.000 000 000 167 (m)

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the values in the question

1

(c) (moles Au = $\frac{0.175}{197}$ =) 0.000888

1

(moles Cl_2 = 0.000888 × $\frac{3}{2}$ =) 0.00133

allow a correct calculation using an incorrectly calculated value of moles of gold

1

(mass Cl_2 =) 0.00133 × 71

allow a correct calculation using an incorrectly calculated value of moles of chlorine

1

= 0.0946 (g)

1

= 94.6 (mg)

allow a correct conversion using an incorrectly calculated mass of chlorine

1

alternative approach:

(from equation 2 moles of Au reacts with 3 moles of Cl_2)
(so) 394 g Au reacts with 213 g Cl_2 (1)

1 g Au reacts with ($\frac{213}{394}$ =)
0.54 g Cl_2 (1)

allow a correct calculation using an incorrectly calculated value of mass of gold and / or chlorine

0.175 g Au reacts with
0.54 × 0.175 g Cl_2 (1)

allow a correct calculation using an incorrectly calculated value of mass of gold and / or chlorine

= 0.0946 (g) (1)

= 94.6 (mg) (1)

allow a correct conversion using an incorrectly calculated mass of chlorine

[10]

9. (a) atomic weight of element

1

(b) gaps

allow spaces / blanks

*do **not** accept undiscovered elements*

1

(c) noble gases

1

(d) 18

this order only

1

22

1

(e) isotopes

1

(f) 2,8,8

1

(g) stable arrangement (of electrons)

allow full outer shell

allow eight electrons in the outer shell

allow does not need to gain or lose electrons

1

[8]