1 The equations below show some reactions of magnesium and its compounds.

A $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

B $Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + O_2(g)$

C $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$

D $Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

(a) Which equation is **not** balanced?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(b) Which equation can be classified as a displacement reaction?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

2 Which of these equations represents the electron affinity of chlorine?

☐ **A** $Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

☐ **B** $Cl_2(g) - 2e^- \rightarrow 2Cl^-(g)$

☐ **C** $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

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

3)

For the oxidation of ammonia

$$a\ NH_3 + b\ O_2 \rightarrow c\ NO + d\ H_2O$$

the values of the coefficients in the balanced equation are

☒ **A** a = 2, b = 3, c = 2 and d = 3

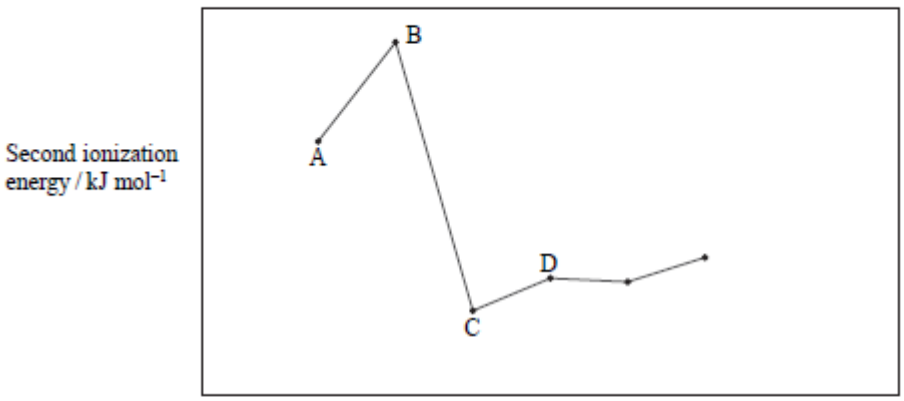
☒ **B** a = 4, b = 7, c = 4 and d = 4

☒ **C** a = 4, b = 5, c = 4 and d = 6

☒ **D** a = 6, b = 7, c = 6 and d = 9

4)

The graph below shows the **second** ionization energy of a series of elements with consecutive atomic numbers.



Which element could be lithium?

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

5)

The first five ionization energies, in kJ mol^{-1}, of aluminium are

578 1817 2745 11 578 14 831

The orbitals from which the first five electrons are removed during ionization, starting with the first electron, are

- ☐ **A** 1s 2s 2p 3s 3p
- ☐ **B** 1s 1s 2s 2s 2p
- ☐ **C** 3p 3s 2p 2s 1s
- ☐ **D** 3p 3s 3s 2p 2p

6 Going across the Periodic Table from sodium to aluminium,

- ☐ **A** the melting temperature increases.
- ☐ **B** the radius of the atom increases.
- ☐ **C** the radius of the metal ion increases.
- ☐ **D** the bonding in the element changes from metallic to covalent.

7 Going down Group 1 from lithium to rubidium

- ☐ **A** the radius of the atom decreases.
- ☐ **B** the radius of the ion decreases.
- ☐ **C** the first ionization energy decreases.
- ☐ **D** the polarizing power of the ion increases.

8 A drop of concentrated nickel(II) sulfate solution, which is green, is placed on moist filter paper on a microscope slide and the ends of the slide are connected to a 24 V DC power supply. After ten minutes,

- ☐ **A** a blue colour has moved towards the negative terminal and a yellow colour towards the positive terminal.
- ☐ **B** a blue colour has moved towards the positive terminal and a yellow colour towards the negative terminal.
- ☐ **C** a green colour has moved towards the negative terminal but there is no other visible change.
- ☐ **D** a green colour has moved towards the positive terminal but there is no other visible change.

9)

Fuel from the air?

A new catalyst that can break down carbon dioxide gas could allow us to use carbon from the atmosphere as a fuel source in a similar way to plants.

Plants break the stable bonds in carbon dioxide during photosynthesis. In the natural process, the carbon dioxide molecule is initially bonded to nitrogen atoms, making reactive compounds called carbamates. Carbamates are derivatives of carbamic acid, NH_2CO_2H. These compounds can then be broken down, allowing the carbon to be used in the synthesis of other plant products such as sugars and proteins.

A new catalyst produced by scientists is a graphite-like compound made from flat layers of carbon and nitrogen atoms arranged in hexagons. Carbon dioxide binds to the catalyst and takes part in the following reaction, which occurs at 150 °C and at about three times atmospheric pressure.

$$\underset{\text{benzene}}{C_6H_6} + CO_2 \rightarrow \underset{\text{phenol}}{C_6H_5OH} + CO$$

Carbon monoxide can then be used to make liquid fuels such as methanol.

The energy required for photosynthesis comes from light, and experiments are now going on to develop a light activated catalyst which could break down carbon dioxide in a new process.

(Source: adapted from an article from the *NewScientist.com* by Tom Simonite, March 2007)

(a) Why are the bonds **within** a layer of carbon atoms in graphite stronger than the bonds **between** the layers of carbon atoms?

(2)

(b) The data below gives the relative electrical conductivity of a pure graphite crystal.

Relative conductivity in plane of carbon hexagons	Relative conductivity perpendicular to plane of carbon hexagons
3.7	0.0017

Explain why the relative electrical conductivity of graphite differs with direction.

(2)

(c) Suggest why the strength of the bond between the layers in graphite would increase if some carbon atoms were replaced with nitrogen atoms.

(2)

(d) Suggest ONE benefit of using a light activated catalyst for the new process.

(1)

(e) The liquid fuel, methanol, is made by reacting carbon monoxide with hydrogen.

Write an equation for this reaction. State symbols are **not** required.

(1)

*(f) Benzene, which is needed for the new process of breaking down carbon dioxide, can be made from coal. It is now usually made by catalytic treatment of one fraction of crude oil at temperatures of around 500 °C and 20 atmospheres pressure.

Suggest the benefits and disadvantages of breaking down carbon dioxide using benzene and the catalyst as described in the passage. You should consider

- the energy and resources needed
- the effects on the atmosphere
- whether it is a beneficial method for producing energy compared to direct use of fossil fuels.

(6)

(g) Carbon exists in forms other than graphite. Nanotubes are rolls of graphite layers, and fullerenes are cages of carbon atoms. Both nanotubes and fullerenes can trap other substances in their structures, and fullerenes can be coated with other substances.

Give ONE application of carbon nanotubes or fullerenes which exploits this behaviour.

(1)

10)

This question is about the element chlorine (atomic number = 17).

(a) Complete the electronic structure of chlorine.

(1)

$1s^2\ 2s^2$ .....

(b) Chlorine forms compounds with magnesium and with carbon.

(i) Draw a dot and cross diagram to show the electronic structure of the compound magnesium chloride (only the outer electrons need be shown). Include the charges present.

(2)

(ii) Draw a dot and cross diagram to show the electronic structure of the compound tetrachloromethane (only the outer electrons need be shown).

(2)

*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

(3)

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)

11)

The melting temperatures of the elements of Period 3 are given in the table below. Use these values to answer the questions that follow.

Element	Na	Mg	Al	Si	P (white)	S (monoclinic)	Cl	Ar
Melting temperature / K	371	922	933	1683	317	392	172	84

(a) Explain why the melting temperature of sodium is very much less than that of magnesium.

(3)

(b) Explain why the melting temperature of silicon is very much greater than that of white phosphorus.

(3)

(c) Explain why the melting temperature of argon is the lowest of all the elements of Period 3.

(1)

(d) Explain why magnesium is a good conductor of electricity whereas sulfur is a non-conductor.

(2)

12)

(a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

(2)

(ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

(2)

(b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

(1)

(c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance .....

Explanation .....

(d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them?
[No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

Equation:

(ii) Suggest another test, other than heating or the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test .....

Result with magnesium carbonate .....

.....

Result with barium carbonate .....