1 Kinetic theory explains the properties of matter in terms of the arrangement and movement of particles.

   (a) Nitrogen is a gas at room temperature. Nitrogen molecules, N_2, are spread far apart and move in a random manner at high speed.

   (i) Draw the electronic structure of a nitrogen molecule.
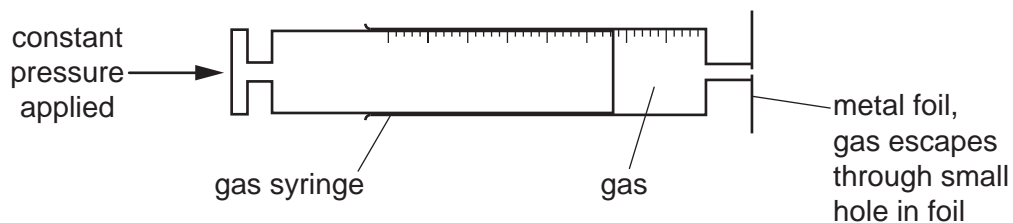   Show only the outer electron shells.

   [2]

   (ii) Compare the movement and arrangement of the molecules in solid nitrogen to those in nitrogen gas.

   ....

   ....

   ....

   .... [3]

   (b) A sealed container contains nitrogen gas. The pressure of the gas is due to the molecules of the gas hitting the walls of the container.
   Use the kinetic theory to explain why the pressure inside the container increases when the temperature is increased.

   ....

   .... [2]

The following apparatus can be used to measure the rate of diffusion of a gas.

constant
pressure ——→
applied

gas syringe   gas

metal foil,
gas escapes
through small
hole in foil

The following results were obtained.

gas	temperature /°C	rate of diffusion in cm^3/min
nitrogen		1.00
chlorine		0.63
nitrogen		1.05

(c)   Explain why nitrogen gas diffuses faster than chlorine gas.

....

.... [2]

  (ii) Explain why the nitrogen gas diffuses faster at the higher temperature.

.... [1]

[Total: 10]

2 Concentrated ammonia solution gives off ammonia gas. Concentrated hydrochloric acid gives off hydrogen chloride gas. Ammonia, NH_3, and hydrogen chloride, HCl, are both colourless gases. Ammonia reacts with hydrogen chloride to make the white solid ammonium chloride.

Apparatus is set up as shown.

cotton wool
soaked in concentrated
hydrochloric acid

cotton wool
soaked in concentrated
ammonia solution

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

glass tube

After ten minutes a white solid forms in the tube where the gases meet.

(a) (i) Write the chemical equation for the reaction of ammonia with hydrogen chloride.

.... [1]

(ii) Name the process by which the ammonia and hydrogen chloride gases move in the tube.

.... [1]

(iii) At which point, **A**, **B**, **C** or **D**, does the white solid form? Explain why the white solid forms at that point.

the solid forms at ....

explanation ....

....
[3]

(iv) The experiment was repeated at a higher temperature.

Predict how the results of the experiment would be different. Explain your answer.

....

....

.... [3]

(b) Some of the white solid is removed from the tube and dissolved in water.

Describe how the white solid could be tested to show it contains,

(i) ammonium ions,

test ....

....

result ....

....
[3]

(ii) chloride ions.

test ....

....

result ....

....
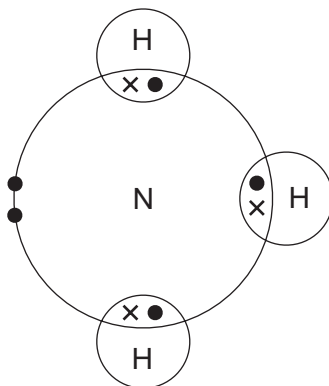[3]

(c) The diagram shows the electron arrangement in a molecule of ammonia, showing only outer shell electrons.

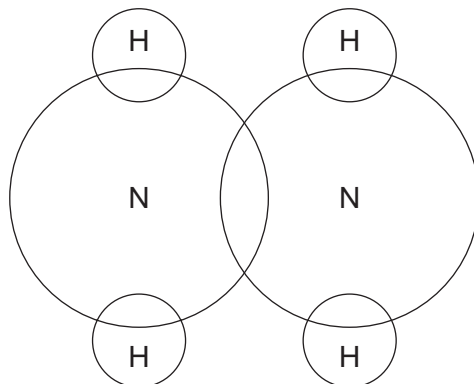**(i)** State the type of bonding in ammonia.

.... [1]

(ii) Hydrazine, N_2H_4, is another compound of nitrogen and hydrogen.

Complete the diagram to show the electron arrangement in a molecule of hydrazine, showing only outer shell electrons.

[3]

(d) Nylon and proteins are both polymers containing nitrogen.

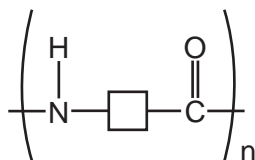**(i)** Name the linkages found in the polymers of nylon and protein.

.... [1]

(ii) Describe **one** difference in the structures of nylon and protein.

.... [1]

(iii) What is the general name given to the products of hydrolysis of proteins?

.... [1]

(e) Suggest the structure of the monomer used to make the polymer shown.

$$\left(\begin{array}{c} \overset{\displaystyle H}{\underset{|}{N}} - \square - \overset{\displaystyle O}{\underset{\parallel}{C}} \end{array}\right)_{n}$$
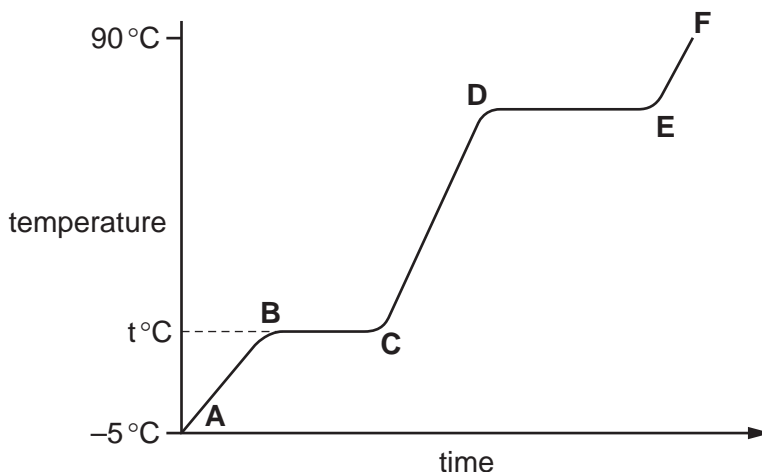
[1]

[Total: 22]

3 Compound X is a colourless liquid at room temperature.

(a) A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.

(i) Complete the equation for the equilibrium present in the region **BC**.

X(s) ⇌ .... [1]

(ii) What is the significance of temperature t °C?

.... [1]

(iii) What is the physical state of compound X in the region **EF**?

.... [1]

(iv) What would be the difference in the region **BC** if an impure sample of X had been used?

.... [1]

(b) Compound X is a hydrocarbon. It contains 85.7% of carbon. The mass of one mole of X is 84 g.

(i) What is the percentage of hydrogen in the compound ?

.... [1]

(ii) Calculate the empirical formula of X. Show your working.

empirical formula = ... [3]

(iii) What is the molecular formula of compound X?

.... [1]

[Total: 9]

4 **(a)** Different gases diffuse at different speeds.

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

....

.... [1]

(ii) What property of a gas molecule affects the speed at which it diffuses?

.... [1]

(b) Helium is a gas used to fill balloons. It is present in the air in very small quantities. Diffusion can be used to separate it from the air.

Air at 1000 °C is on one side of a porous barrier. The air which passes through the barrier has a larger amount of helium in it.

(i) Why does the air on the other side of the barrier contain more helium?

.... [1]

(ii) Why is it an advantage to have the air at a high temperature?

....

.... [1]

(c) Most helium is obtained from natural gas found in the USA. Natural gas contains methane and 7% helium. One possible way to obtain the helium would be to burn the methane.

(i) Write an equation for the complete combustion of methane.

.... [1]

(ii) Suggest why this would **not** be a suitable method to obtain the helium.

....

.... [1]

(iii) Suggest another method, other than diffusion, by which helium could be separated from the mixture of gases in natural gas.

.... [1]
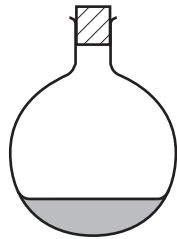
[Total: 7]

5 Explain each of the following in terms of the kinetic particle theory.

(a) The rate of most reactions increases at higher temperatures.

....

....

....

.... [3]
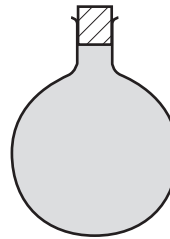
(b) A liquid has a fixed volume but takes up the shape of the container. A gas takes up the shape of the container but it does not have a fixed volume.
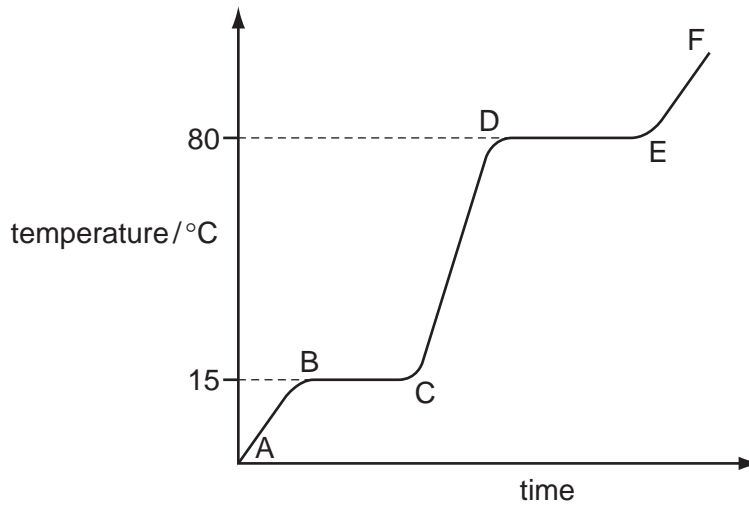
liquid   gas

....

....

....

....

.... [3]

[Total: 6]

6 The diagram shows a heating curve for a sample of compound X.

(a) Is X a solid, a liquid or a gas at room temperature, 20 °C?

.... [1]

(b) Write an equation for the equilibrium which exists in region BC.

.... [2]

(c) Name the change of state which occurs in region DE.

.... [1]

(d) Explain how the curve shows that a pure sample of compound X was used.

....

.... [2]

[Total: 6]