3. Chemical bonding

3.6 Intermolecular forces

Paper 2

Question Paper

1 **(d)** Fig. 3.2 shows the boiling points of the simplest hydrides of the Group 14 elements, C to Pb.

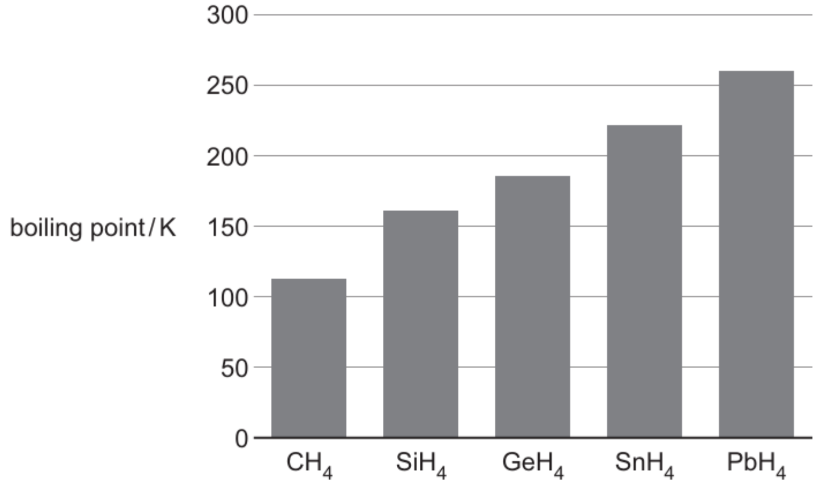

Fig. 3.2

(i) Explain the trend in the boiling points of the Group 14 hydrides shown in Fig. 3.2.

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.... [2]

(ii) Deduce the shape of a molecule of SiH_4.

.... [1]

2 **(c)** Fig. 2.1 shows the boiling points of H_2O and other Group 16 hydrides.

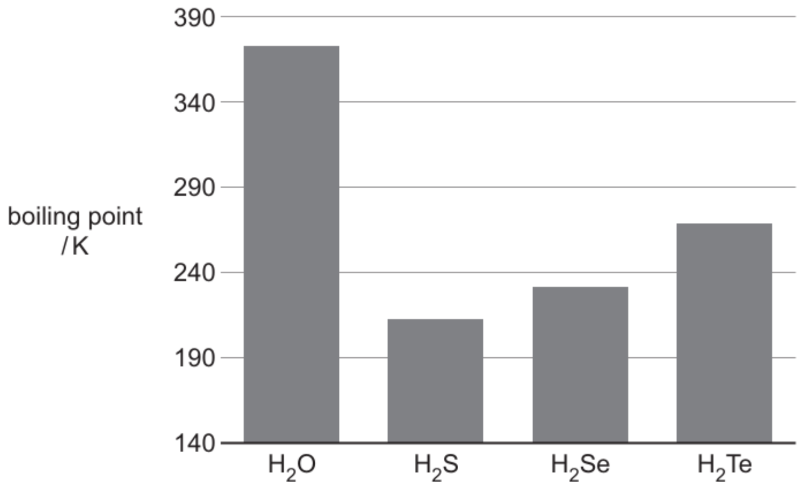

Fig. 2.1

(i) Explain the trend in the boiling points of the Group 16 hydrides H_2S to H_2Te.

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.... [2]

(ii) Explain why the boiling point of H_2O is much higher than that of H_2S.

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.... [1]

3 **(b) (iii)** Name the strongest intermolecular force that exists between NH_3(l) molecules.

.... [1]

(iv) Draw a diagram to show the formation of the strongest intermolecular force between **two** molecules of NH_3(l).

Include any relevant lone pairs of electrons and dipoles.

[2]

(v) The melting points of ice and ammonia are shown in Table 1.2.

Table 1.2

solid	melting point / K
ice	273
ammonia	195

Suggest **two** reasons for the difference in the melting points of ice and ammonia.

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.... [2]

4 Lactic acid, $CH_3CH(OH)COOH$, and pyruvic acid, $CH_3COCOOH$, both contain two functional groups.

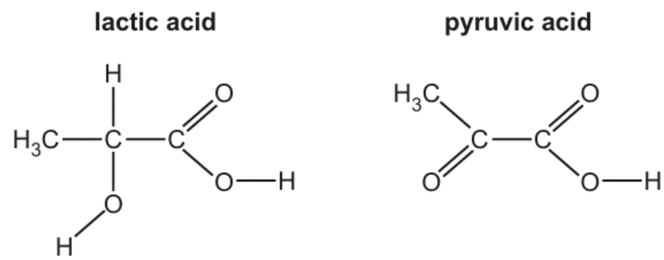


Fig. 4.1

(a) (iii) Lactic acid forms hydrogen bonds with water.

Complete Fig. 4.2 to show the formation of a hydrogen bond between one molecule of lactic acid and one molecule of water.

Label the hydrogen bond. Show any relevant dipoles and lone pairs of electrons.

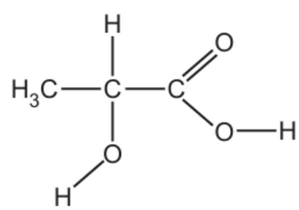
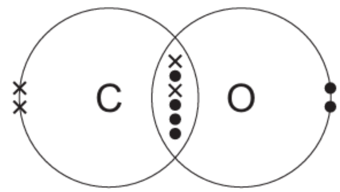


Fig. 4.2

[3]

5 Carbon monoxide gas, $CO(g)$, and nitrogen gas, $N_2(g)$, are both diatomic molecules.

(a) The diagram shows the arrangement of outer electrons in a molecule of $CO(g)$.



(ii) The table states the electronegativity values of carbon, nitrogen and oxygen atoms.

	C	N	O
electronegativity	2.5	3.0	3.5

Use the electronegativity values and relevant details from the *Data Booklet* to complete the table below.

	N_2	CO
number of electrons per molecule		
type(s) of intermolecular (van der Waals') force		

[2]

(b) $N_2(g)$ is less reactive than $CO(g)$ even though $N_2(g)$ has a lower bond energy than $CO(g)$.

Suggest why $CO(g)$ is more reactive than $N_2(g)$.

....

.... [1]

6 The strength of interaction between particles determines whether the substance is a solid, liquid or gas at room temperature.

(c) Nitrogen, N_2, is also a gas at room temperature and pressure. Neither CO nor N_2 is an ideal gas.

(iii) Complete the table by naming **all** the types of intermolecular forces (van der Waals') in separate samples of $N_2(g)$ and CO(g).

	$N_2(g)$	CO(g)
number of electrons per molecule	14	14
presence of a dipole moment	✗	✓
boiling point / °C	–195.8	–191.5
intermolecular forces (van der Waals')		

[2]

(iv) Suggest why the bond in a molecule of CO contains a dipole moment.

.... [1]

7 Hydrogen iodide, HI, is a colourless gas at room temperature.

(a) (i) Explain why HI has a higher boiling point than HC*l* and HBr.

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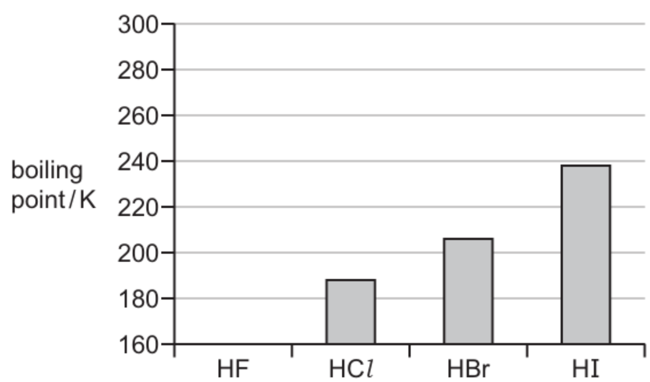
.... [2]

(ii) The bar chart shows the boiling points of HC*l*, HBr and HI. The boiling point of HF is not shown.



Hydrogen bonds form between HF molecules.

Draw a bar on the bar chart to predict the boiling point of HF.

Explain your answer.

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.... [2]

8 Magnesium silicide, Mg_2Si, is a compound made by heating magnesium with sand.

(d) The table shows the electronegativity values of carbon, hydrogen and silicon.

element	carbon	hydrogen	silicon
electronegativity	2.5	2.1	1.8

(i) C–H and Si–H bonds have weak dipoles.

Use the electronegativity values in the table to show the polarity of the C–H and Si–H bonds.

C—H Si—H

[2]

(ii) Explain why methane, CH_4, has no overall dipole moment.

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.... [2]

9 Crude oil is a complex mixture of hydrocarbon molecules.

The hydrocarbon molecules in crude oil are separated by fractional distillation. Fractional distillation is used because the different hydrocarbon molecules in crude oil have different boiling points.

(a) Explain why the hydrocarbon molecules in crude oil have different boiling points.

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.... [2]