(c) Element **E** is in Period 3 of the Periodic Table.
The first eight ionisation energy values of **E** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol^{-1}	577	1820	2740	11 600	14 800	18 400	23 400	27 500

Deduce the full electronic configuration of **E**.
Explain your answer.

full electronic configuration of **E** = ...

explanation .....

.....

.....

[3]

[Total: 9]

1 Fig. 1.1 shows how **first** ionisation energies vary across Period 2.

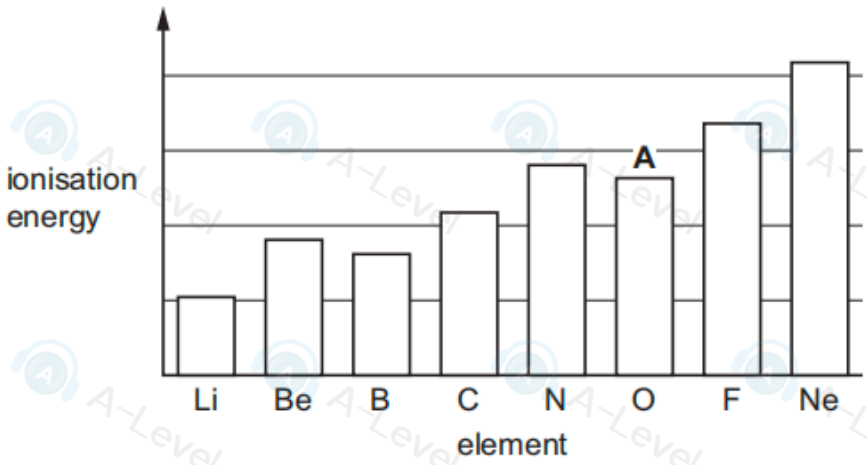

Fig. 1.1

(a) Construct an equation to represent the **first** ionisation energy of oxygen. Include state symbols.

..... [1]

(b) (i) State and explain the general trend in first ionisation energies across Period 2.

.....

.....

.....

.....

..... [3]

(ii) Explain why ionisation energy **A** in Fig. 1.1 does **not** follow the general trend in first ionisation energies across Period 2.

.....

.....

.....

..... [2]

(c) HI(g) can be formed by reacting $H_2(g)$ with $I_2(g)$. The reaction is reversible, and an equilibrium forms quickly at high temperatures.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) Construct an expression for the equilibrium constant, K_p, for the reaction of $H_2(g)$ and $I_2(g)$ to form HI(g).

K_p =

[1]

(ii) The equilibrium partial pressures of the gases at 200 °C are as follows.

$$p_{H_2(g)} = 895\,Pa$$
$$p_{I_2(g)} = 895\,Pa$$
$$p_{HI(g)} = 4800\,Pa$$

Calculate K_p for this reaction.

K_p = ... [1]

(iii) State how the value of K_p would change, if at all, if the reaction were carried out at 100 °C rather than 200 °C.

Explain your answer.

.....

.....

.....

..... [2]

1 The melting points of some solids are shown in Table 1.1.

Table 1.1

solid	melting point / K
magnesium	923
phosphorus	317
sodium chloride	1074
sulfur	392

(a) (i) State the type of bonding present in magnesium and in sodium chloride.

bonding in magnesium .....

bonding in sodium chloride .....

[1]

(ii) Explain the difference in the melting points of magnesium and sodium chloride.

.....

..... [1]

(iii) Explain the difference in the melting points of phosphorus and sulfur in terms of structure and bonding.

.....

.....

..... [2]

(b) (i) Define electronegativity.

.....

..... [1]

(ii) Explain why electronegativity increases across a period.

.....

.....

..... [2]

(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.

.....

.....

..... [2]

[Total: 12]

2 NO and NO_2 react at 25 °C to give N_2O_3 as shown in the equation.

$$NO(g) + NO_2(g) \rightleftharpoons N_2O_3(g) \qquad \Delta H = -7.2\,kJ\,mol^{-1}$$

The reaction is reversible and reaches equilibrium in a closed system.

(a) Fig. 2.1 shows how the rate of the forward reaction changes with time.

Initially, the rate of the reverse reaction is zero.

Complete Fig. 2.1 to sketch how the rate of the **reverse** reaction changes with time.

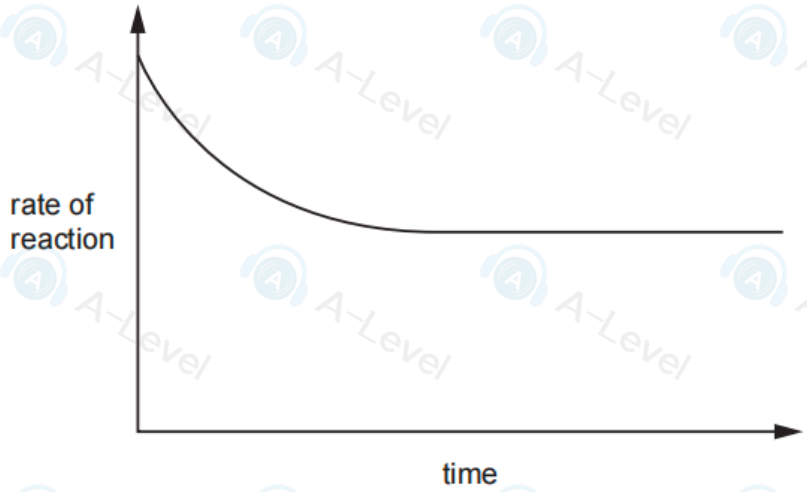

Fig. 2.1

[1]

(b) State how the position of equilibrium changes, if at all, when the reaction takes place at 100 °C.

Explain your answer.

Assume the pressure remains constant.

.....

.....

.....

..... [2]

(c) Table 2.1 shows the composition of an equilibrium mixture of NO(g), NO_2(g) and N_2O_3(g) at 101 kPa.

Table 2.1

gas	number of moles at equilibrium / mol
NO	0.605
NO_2	0.605
N_2O_3	0.390

Calculate K_p, the equilibrium constant with respect to partial pressures.

Deduce the units of K_p.

K_p = ... units .....

[3]

(d) Identify one natural process and one man-made process that cause the formation of atmospheric NO and NO_2.

natural process .....

man-made process .....

[2]

(b) Complete Table 1.1 to show the total numbers of protons and electrons in the molecular ions NH_4^+, CO_3^{2-} and PO_4^{3-}.

Table 1.1

molecular ion	total number of protons	total number of electrons
NH_4^+		
CO_3^{2-}		
PO_4^{3-}		

[3]

(c) NH_4^+ is a Brønsted–Lowry acid.

(i) Define Brønsted–Lowry acid.

.....

..... [1]

(ii) When $NH_4^+(aq)$ is heated with NaOH(aq), a pungent gas is produced.

Write an ionic equation for this reaction.

..... [1]

2 **(a)** Table 1 gives physical data for some of the Period 3 elements.

Table 1

atomic number, *Z*	11	12	13	14	15	16	17
bonding present in element	M						C
first ionisation energy / kJ mol^{-1}	494	736	577	786	1060	1000	1260
maximum oxidation number							+7
anionic radius / nm	–	–	–	0.271	0.212	0.184	0.181

(i) Complete the row in the table labelled 'bonding present in element'.

Use C = covalent, I = ionic, M = metallic, as appropriate. [1]

(ii) Explain the difference between the first ionisation energies of the elements with atomic numbers 11 and 17.

.....

.....

.....

.....

..... [2]

(iii) Explain the difference between the first ionisation energies of the elements with atomic numbers 15 and 16.

.....

.....

.....

.....

..... [2]

(iv) Complete the row in the table labelled 'maximum oxidation number'. [1]

(v) Explain the variation in anionic radius for the elements with atomic numbers 14 to 17.

.....

.....

.....

..... [2]