1. 0620/41/O/N/19/No.7

   This question is about ethanol.

   (a) Ethanol that is suitable for use as a fuel can be manufactured from sugars such as glucose, $C_6H_{12}O_6$, by a two-step process.

   Describe how this can be done. In your answer, include:

   - an equation for the reaction in which ethanol is formed
   - the essential conditions for the reaction in which ethanol is formed
   - the name of the process used to obtain ethanol that is pure enough to use as a fuel from the reaction mixture.

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   .... [5]

(b) The equation for the complete combustion of ethanol is shown.

$$\text{H---C---C---O---H} + 3\ \text{O}{=}\text{O} \rightarrow 2\ \text{O}{=}\text{C}{=}\text{O} + 3\ \text{H---O---H}$$
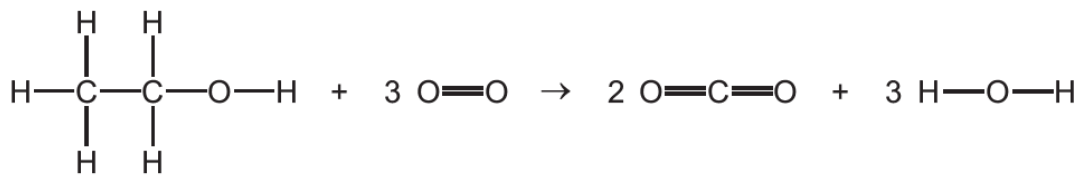
Use the bond energies in the table to calculate the energy change, in kJ/mol, for the complete combustion of ethanol.

bond	bond energy in kJ/mol
C–C	347
C–H	413
C–O	358
C=O	805
O–H	464
O=O	498

● Energy needed to break bonds.

.... kJ

● Energy released when bonds are formed.

.... kJ

● Energy change for the complete combustion of ethanol.

energy change = ... kJ/mol

[3]

2

(c) Ethanol can be oxidised by hydrogen peroxide to form ethanal, CH_3CHO. A catalyst for this reaction is Fe^{3+}.

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

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.... [2]

(ii) The structure of ethanal is shown.

$$H-\overset{\overset{\textstyle H}{|}}{\underset{\underset{\textstyle H}{|}}{C}}-\overset{}{\underset{\underset{\textstyle H}{|}}{C}}=O$$
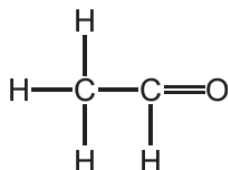
Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Show outer shell electrons only.
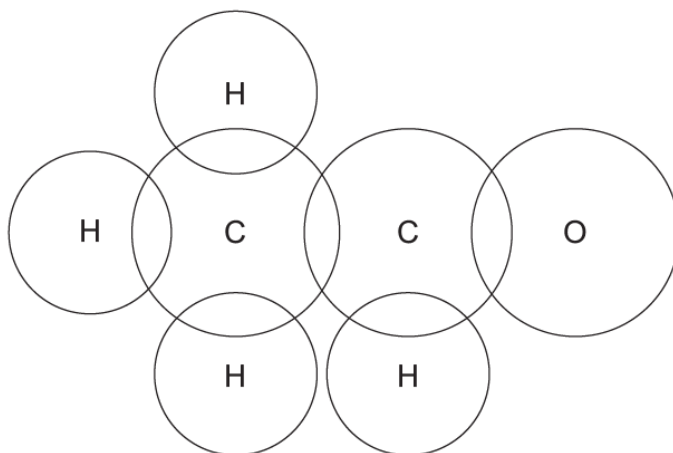
[3]

(iii) The table gives the boiling points of ethanal and ethanol.

substance	boiling point/°C
ethanal	20
ethanol	78

In terms of attractive forces between particles, suggest why ethanal has a lower boiling point than ethanol.

....

.... [1]

3

(d) Ethene gas reacts with steam to form gaseous ethanol.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$$
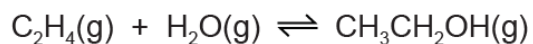
The reaction can reach a position of equilibrium. The forward reaction is exothermic.

(i) State and explain the effect of increasing the pressure on the **position of equilibrium**. All other conditions are unchanged.

....

....

.... [2]

(ii) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the reaction. All other conditions are unchanged.

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.... [2]

(iii) State and explain the effect of increasing the temperature on the **position of equilibrium**. All other conditions are unchanged.

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.... [2]

[Total: 20]

2.

This question is about phosphorus and compounds of phosphorus.

(a) A phosphorus molecule contains four phosphorus atoms **only**.

What is the formula of a phosphorus molecule?

.... [1]

(b) Phosphorus reacts with chlorine gas to produce phosphorus(III) chloride, PCl_3.

    (i) Write a chemical equation for the reaction between phosphorus and chlorine to produce phosphorus(III) chloride, PCl_3.

      .... [2]

    (ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3. Show outer shell electrons only.

[2]

5
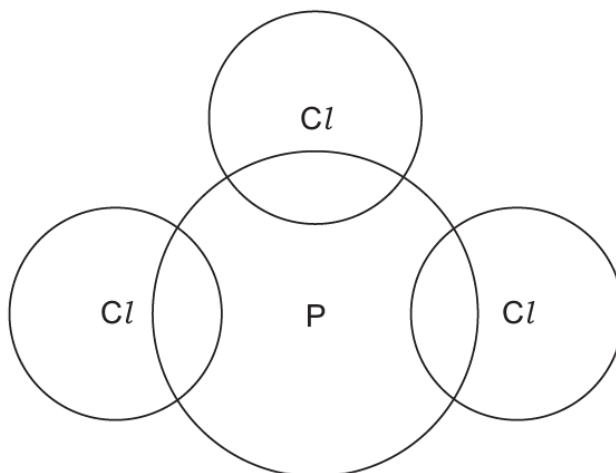
(c) Gaseous phosphorus(III) chloride, PCl_3, reacts with gaseous chlorine to form gaseous phosphorus(V) chloride, PCl_5.

$$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$$
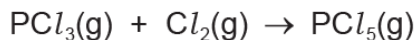
The chemical equation for this reaction can be represented as shown.
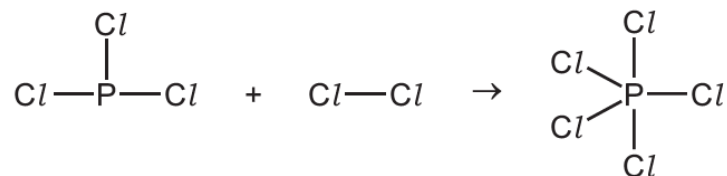
(i) Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

bond	bond energy in kJ/mol
P–Cl	326
Cl–Cl	243

- Energy needed to break bonds.

.... kJ

- Energy released when bonds are formed.

.... kJ

- Energy change of reaction.

energy change = ... kJ/mol
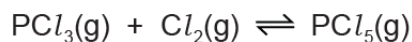
[3]

(ii) Deduce whether the energy change for this reaction is exothermic or endothermic. Explain your answer.

....

.... [1]

(d) Under certain conditions the reaction reaches equilibrium.
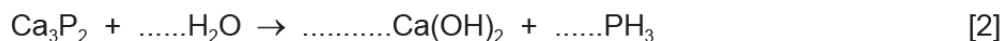
$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

State and explain the effect, if any, on the **position of equilibrium** if the pressure is increased. All other conditions are unchanged.

....

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.... [2]

(e) Phosphine, PH_3, is produced by the reaction between water and calcium phosphide, Ca_3P_2.

Balance the chemical equation for this reaction.

$$Ca_3P_2 + \ldots\ldots H_2O \rightarrow \ldots\ldots\ldots Ca(OH)_2 + \ldots\ldots PH_3$$ [2]

(f) The phosphonium ion, PH_4^+, is similar to the ammonium ion.

(i) State the formula of the ammonium ion. .... [1]

(ii) Suggest the formula of phosphonium iodide. .... [1]

(g) Calcium phosphate contains the phosphate ion, PO_4^{3-}.

What is the formula of calcium phosphate?

.... [1]

(h) Phosphorus forms another compound with hydrogen with the following composition by mass: P, 93.94%; H, 6.06%.

(i) Calculate the empirical formula of the compound.

empirical formula = ... [2]

(ii) The compound has a relative molecular mass of 66.

Deduce the molecular formula of the compound.

molecular formula = ... [1]

[Total: 19]