

QUESTION ONE

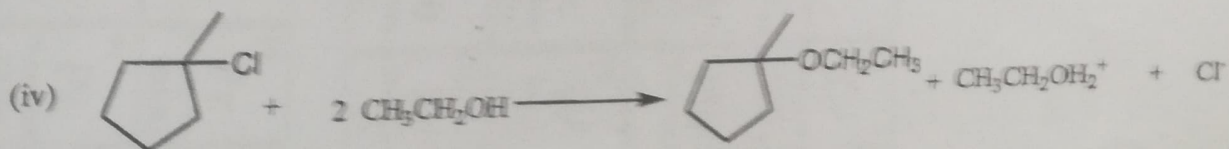
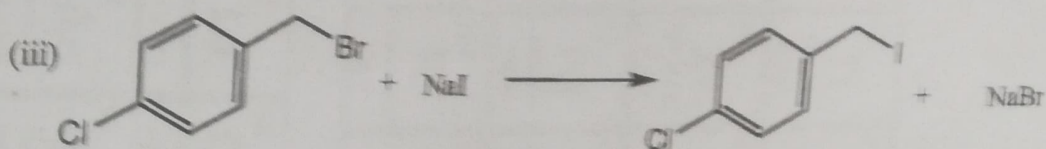
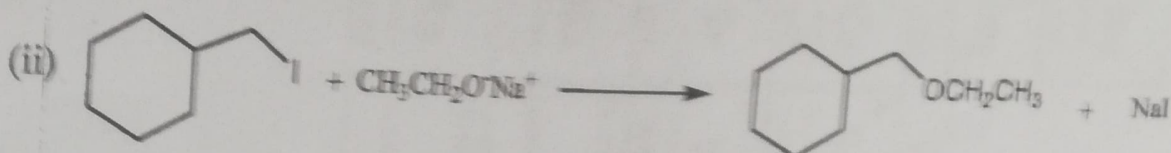
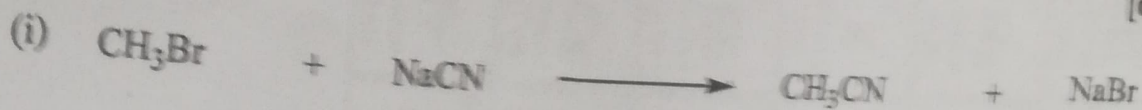
The unique properties of water make life possible on Earth. Approximately three-quarters of the Earth's surface is covered by water. Cells are made up of around 70-95% water. Water comprises roughly 70% of the human body.

- (a) Describe the major physical and chemical properties of water that make it unique from other liquids. [10 marks]
- (b) Explain the properties of water that enable it to travel up through the roots and stems of plants to reach the leaves. [10 marks]

QUESTION TWO

- (a) A 0.40 M solution of the lactate ion ($C_3H_5O_3^-$) (a weak base), has a pH of 8.728.
- (i) Calculate the K_b of the lactate ion ($C_3H_5O_3^-$). [4 marks]
- (ii) Using the information from (2a), calculate the K_a for lactic acid ($HC_3H_5O_3$). [1 mark]
- (b) The weak base ethylamine ($C_2H_5NH_2$) has a K_b of 6.4×10^{-4} .
- (i) Write the equilibrium equation for the ionization of ethylamine. [1 mark]
- (ii) What $[C_2H_5NH_2]$ is required to produce an ethylamine solution with a pH = 12.102? [4 marks]
- (c) The pH in a 0.25 M solution of the acid HBrO is 4.65.
- (i) Using this data above, calculate the value of K_a for the acid, HBrO. [4 marks]
- (ii) Calculate the pH of a 0.22M solution of the salt $NaNO_2$, where K_a for HNO_2 is 7.2×10^{-4} . [3 marks]
- (iii) The value of K_b for the weak base methylamine (CH_3NH_2) is 4.4×10^{-4} . Calculate the value of K_a for the acid $CH_3NH_3^+$. [3 marks]

(b) Write the following net ionic equations and designate the nucleophile, substrate and leaving group in each reaction. [6 marks]



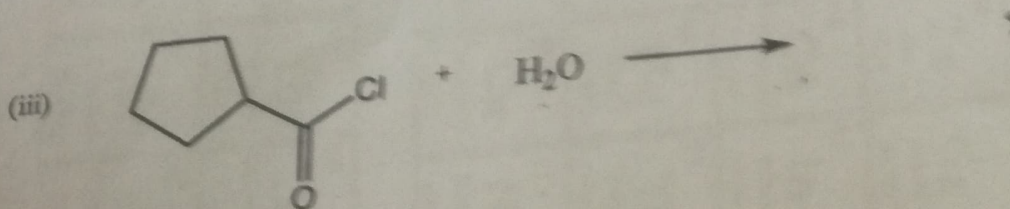
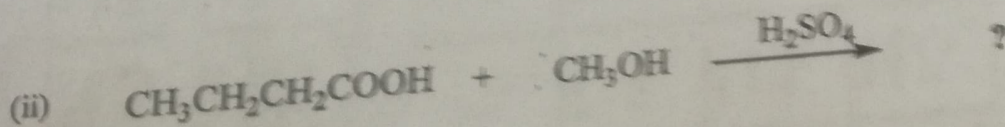
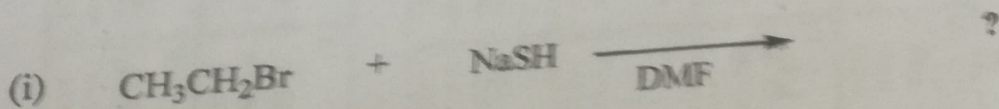
(c) Draw the general structure of an alpha amino acid. [1 mark]

(d) Give a known example of an alpha amino acid. [1 mark]

[1 mark]

[1 mark]

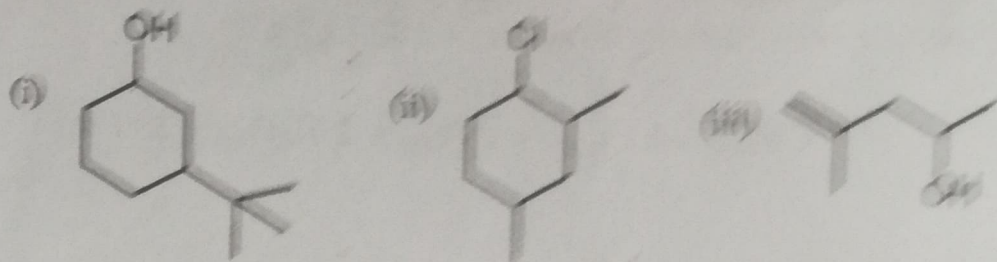
(e) Predict the product of the following reactions: [4 marks]



END OF EXAMINATION

(d) Name the following compounds:

(2 marks)



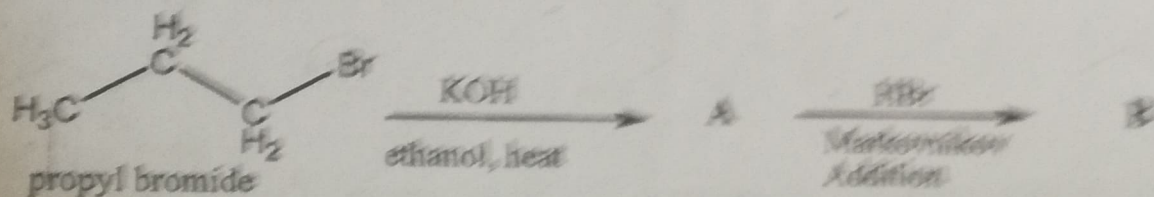
(e) Draw bond line formulas for the following compounds:

(4 marks)

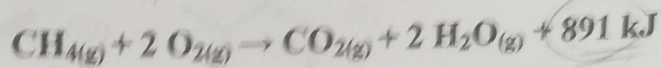
- (i) Ethyl-2-methylbutanoate
- (ii) 3-bromopentanal
- (iii) 4-hydroxy-2-methylpentanoic acid

QUESTION SIX

(a) Consider the following reaction of propyl bromide (1-bromopropane) with hot alcoholic potassium hydroxide shown below. An elimination reaction takes place instead of a nucleophilic substitution reaction.



normal boiling point? Assume that all of the heat generated by the burner is absorbed by the water. (Specific heat capacity of water: $4.182 \text{ J g}^{-1} \text{ C}^{-1}$).



[6 marks]

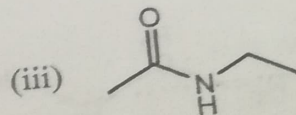
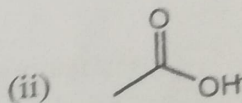
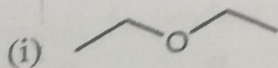
- (c) A 28.5 g piece of metal at 99.8°C is placed in a calorimeter containing 50.0 g of water at 22.3°C . The calorimeter itself has a heat capacity of $3.40 \text{ J/g}^\circ\text{C}$, and the temperature rises to 26.1°C . Calculate the specific heat capacity of the metal ($\text{J/g}^\circ\text{C}$).

[6 marks]

QUESTION FIVE

- (a) What functional group is present in each of the following molecules?

[6 marks]

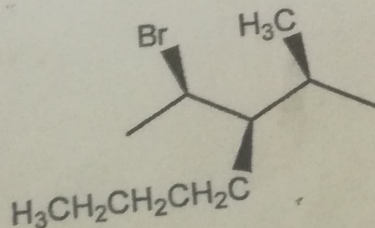


- (b) Provide a molecule that contains the indicated functional group. Do not include multiple functional groups in the molecules you draw.

[4 marks]

- (i) Alkene
(ii) ketone

- (c) Determine the absolute configuration of any stereogenic centres in the following molecule. Show your reasoning for full credit.



[4 marks]

QUESTION THREE

- (a) Given that a phase reaction $A + B \rightarrow C$ has a reaction rate which is experimentally observed to follow the relationship $\text{Rate} = k[A]^2[B]$. What factors would affect the value of the specific rate constant, k ? [4 marks]
- (b) The rate constant for a particular reaction is $1.3 \times 10^{-4} \text{M}^{-1}\text{s}^{-1}$ at 100°C , and $1.1 \times 10^{-4} \text{M}^{-1}\text{s}^{-1}$ at 150°C . What is the overall order of the reaction? [4 marks]
- (c) Consider the following hypothetical data for the reaction Experimental kinetics dealing with one chemical species:

$2\text{NO}_2 \rightarrow 2\text{NO} + \text{O}_2$

$[\text{NO}_2]$ (M)	0.30	0.15	0.075	0.038
Time(min)	0	2.0	4.0	6.0

- (i) Calculate the order of this reaction and write the complete rate law. [4 marks]
- (ii) Calculate the half-life for this reaction? [4 marks]
- (iii) Calculate the rate constant for this reaction? [4 marks]

QUESTION FOUR

- (a) Answer the questions below for each of the following reaction coordinate diagrams:

