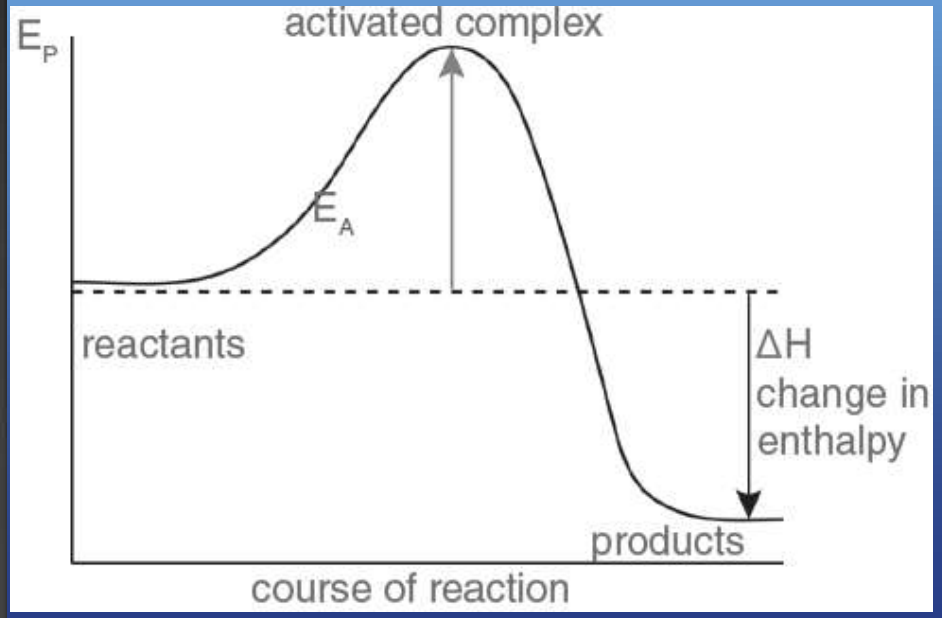
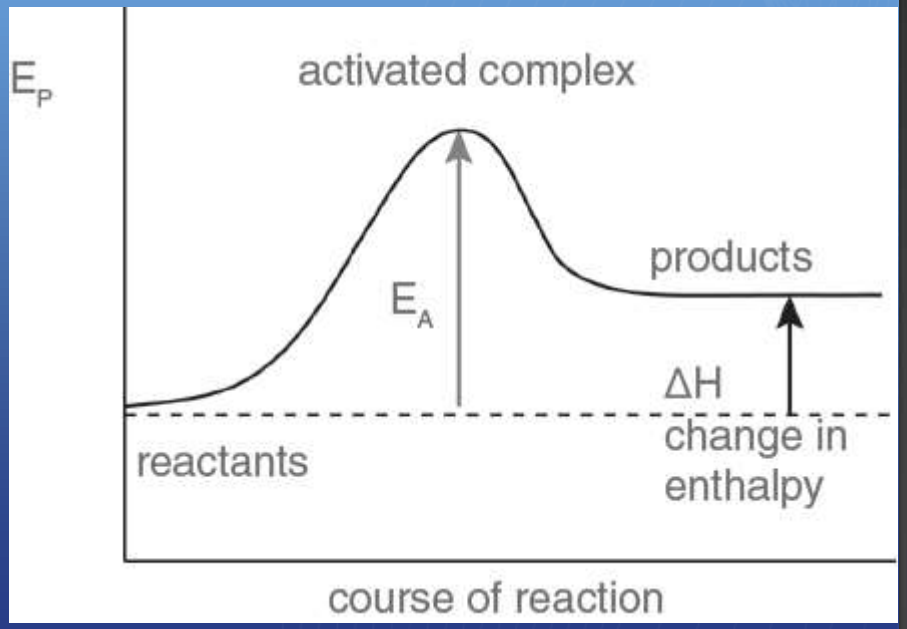
EXERCISE 22

CHEMICAL CHANGE

PAGE 258

1. Draw an energy diagram for each of an exothermic and an endothermic reaction and indicate the following on the diagram:
   1. reactants
   2. products
   3. activation energy
   4. Δ H





2 Are the following reactions exothermic or endothermic:

2.1 $S + O_2 \rightarrow SO_2$ (ΔH is negative.)

Exothermic

2.2 $A + B + \text{energy} \rightarrow AB$

Endothermic

2.3 Food is digested.

Exothermic

2.4 $NH_4C\ell(s) \rightarrow NH_4^+(aq) + C\ell^-(aq)$ ($\Delta H > 0$)

Endothermic

2.5 $A_2(g) + B_2 \rightarrow 2AB(g)$ ($\Delta H = +\ 80\ kJ{\cdot}mol^{-1}$)

Endothermic

2.6 $CO_2 + H_2O$ + energy → glucose and oxygen

Endothermic

2.7 $A_2 + B \rightarrow A_2B$ ($\Delta H > 0$)

Endothermic

2.8 Acid is diluted in water.

Exothermic

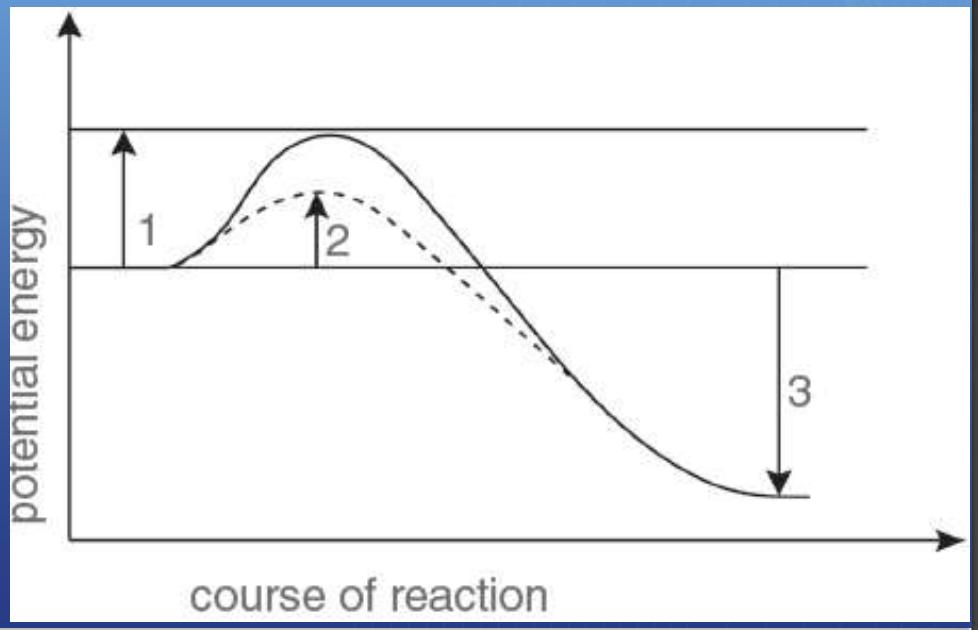
3 The energy diagram below indicates the energy change during a chemical reaction.

3.1 Name the energies 1 – 3.

1: Activation energy without a catalyst

2: Activation energy with a catalyst

3: Change in enthalpy/heat of reaction (ΔH)



3.2 Does the graph represent an exothermic or endothermic reaction?

Exothermic reaction

3.3 Write down the formula for calculating ΔH.

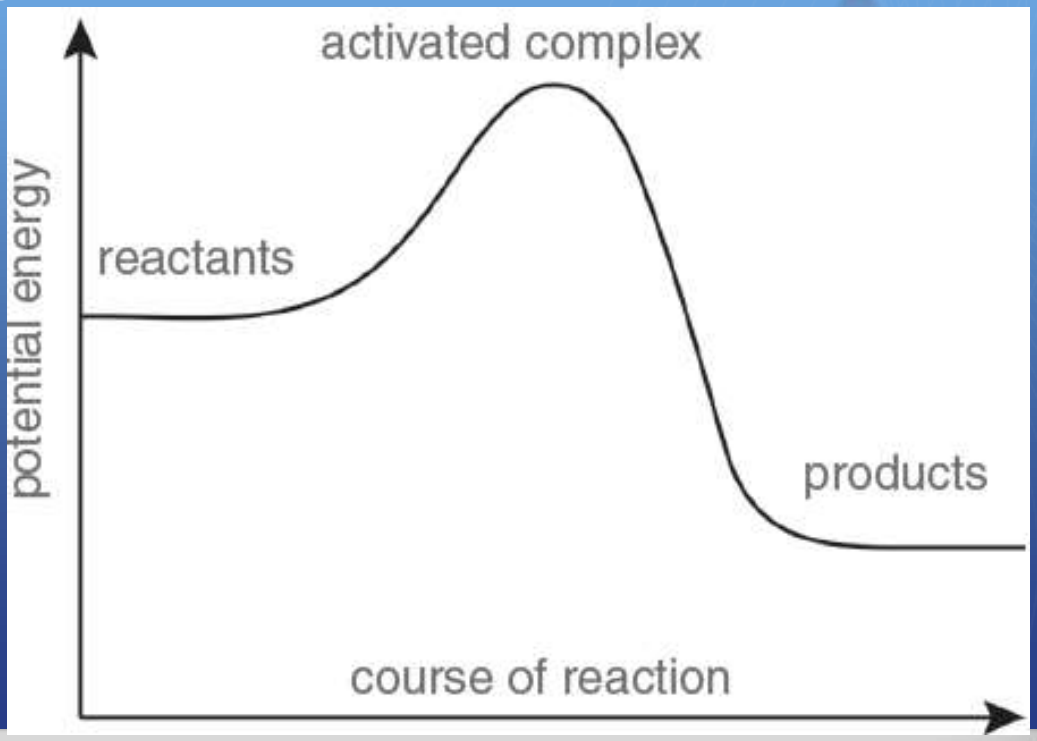
$\mathbf{\Delta H = E_{products} - E_{reactants}}$

4 Sulfur precipitates are often found in crude oil. The sulfur dissolves in the oil.
When the oil is purified to manufacture petrol and diesel, as much as possible of the sulfur must be removed.

If it is not removed, it forms sulfur dioxide when it burns, which causes extensive pollution.

The graph to the right represents the energy change that occurs during the reaction.

$S(s) + O_2(g) \rightarrow SO_2(g)$



4.1 Is the above reaction exothermic or endothermic? Give a reason for your answer.

Exothermic: energy of the products is less than the energy of the reactants.

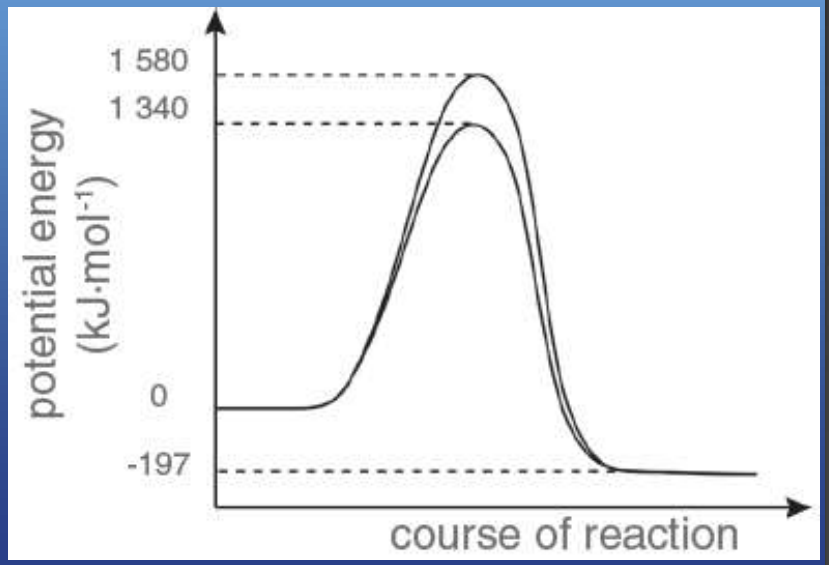
4.2 Sulfur that is extracted from crude oil lies in an open container, which is exposed to the air, without reacting. Use the diagram to explain, in terms of the energy of the particles, why this is so.

For the reaction to take place, the particles must have sufficient kinetic energy (activation energy)when colliding to form an activated complex.

The surroundings do not supply enough energy; therefore the available activation energy is too low.

5 The contact process is used to produce sulfuric acid, which is needed in high concentration for industrial processes. The basis of this process involves the oxidation of sulfur dioxide in the presence of vanadium(V) oxide as a catalyst.

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$



Study the graph (not drawn to scale), which indicates the change in the chemical potential energy for the above-mentioned reaction. Use the reaction equation and the graph, where necessary, to answer the following questions.

5.1 Is the forward reaction exothermic or endothermic? Justify your answer by writing down the value of ΔH for this reaction.

Exothermic:

$\Delta H = E_{products} - E_{reactants}$

$= -197 - 0$

$= -197$ kJ

5.2 Write down the activation energy for the forward reaction in the absence of vanadium(V) oxide as catalyst.

1 580 kJ·mol^{-1}

5.3 If we assume that 1 580 kJ·mol^{-1} is involved to break the bonds in the $SO_2(g)$ and $O_2(g)$ molecules, how much energy is released when new bonds in the $SO_3(g)$ molecules form?

Energy released = 1 580 - (-197) = 1 777 kJ·mol^{-1}

5.4 Determine the activation energy for the reverse reaction in the presence of the vanadium(V) oxide catalyst.

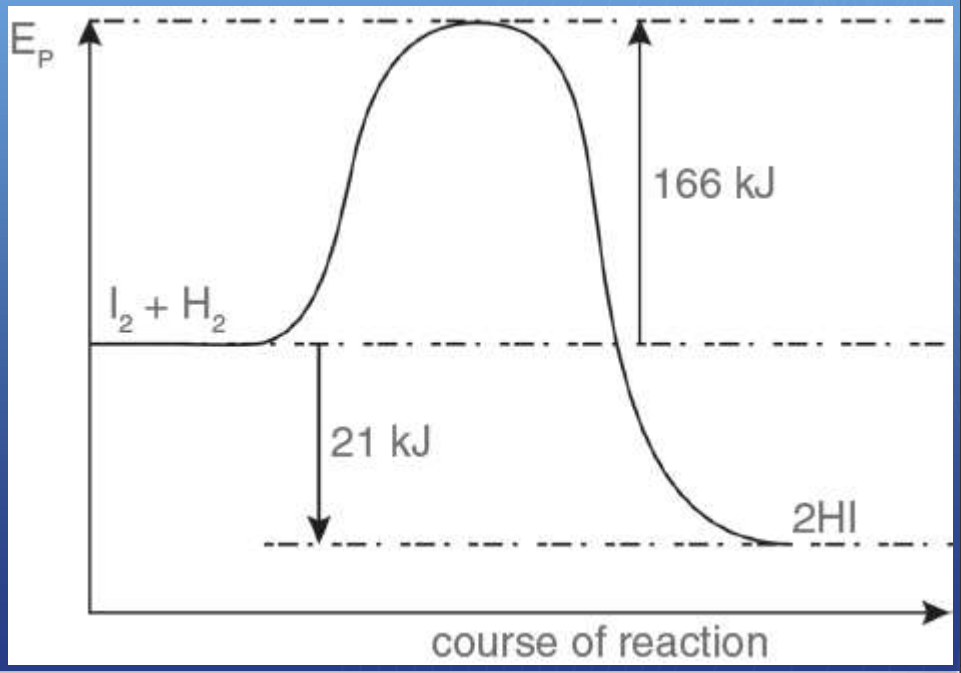
E_A (reverse reaction without a catalyst)

= 1 340 + 197

= 1 537 kJ·mol^{-1}

6 Study the potential energy curve for the course of the equilibrium reaction:

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



6.1 What is the activation energy for the forward reaction?

166 kJ

6.2 What is ΔH for the forward reaction?

-21 kJ

6.3 Is the reverse reaction exothermic or endothermic?

Endothermic

6.4 What is the activation energy for the reverse reaction?

166 + 21 = 187 kJ

6.5 How would a catalyst influence the reaction?

A catalyst lowers the activation energy, and therefore increases the rate of the reaction.