P.183

1. The second reaction is more likely to be reversible since its enthalpy change is low and the activation energies of the direct and reverse reactions are very similar.

2. *a)* Endothermic

   *b)* $\Delta H_{reaction} = H_{products} - H_{reactants}$
   $= 143 \text{ kJ/mol} - 103 \text{ kJ/mol}$
   $= 40 \text{ kJ/mol}$

   $E_a = 157 \text{ kJ/mol} - 103 \text{ kJ/mol} = 54 \text{ kJ/mol}$

   *c)* The enthalpy change of the reverse reaction is the same, but of the opposite sign:
   $\Delta H_{reverse\ reaction} = -40 \text{ kJ/mol}$
   $E_a = 157 \text{ kJ/mol} - 143 \text{ kJ/mol} = 14 \text{ kJ/mol}$

   This reaction could be reversible given its enthalpy change of 40 kJ/mol, which is low.

3. *a)* Graphs 1 and 3.

   *b)* Graph 2.

   *c)* Reaction 3 and its reverse reaction, reaction 4, since the enthalpy change is low and therefore, the activation energies of the direct and reverse reactions are very similar.

   *d)* Reaction 2, since it has the lowest activation energy.

   *e)* Reaction 1: $\Delta H_{reaction} = 75 \text{ kJ/mol}$
   $E_a = 100 \text{ kJ/mol}$
   Reaction 2: $\Delta H_{reaction} = -75 \text{ kJ/mol}$
   $E_a = 25 \text{ kJ/mol}$
   Reaction 3: $\Delta H_{reaction} = 25 \text{ kJ/mol}$
   $E_a = 100 \text{ kJ/mol}$
   Reaction 4: $\Delta H_{reaction} = -25 \text{ kJ/mol}$
   $E_a = 75 \text{ kJ/mol}$

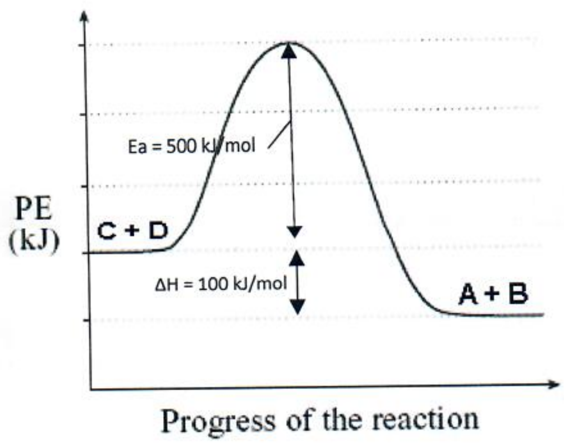
4. *a)* $C + D \rightarrow A + B$ is exothermic since it has the lowest activation energy, indicating that the potential energy of the reactants is greater than that of the products.

*b)* $|\Delta H| = 600\ kJ/mol - 500\ kJ/mol = 100\ kJ/mol$

$A + B \rightarrow C + D\ \Delta H_{reaction} = 100\ kJ/mol$

$C + D \rightarrow A + B\ \Delta H_{reaction} = -100\ kJ/mol$

*c)* Reaction $C + D \rightarrow A + B$ will be faster since it has the lowest activation energy.

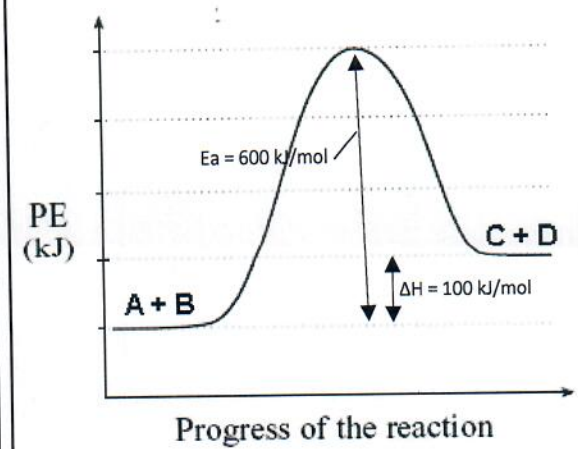



Reverse Reaction

ΔH = -100 kJ/mol

Ea = 500 kJ/mol

Exo




Forward Reaction

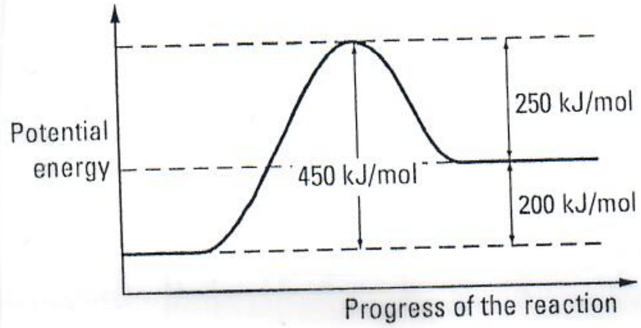
ΔH = 100 kJ/mol

Ea = 600 kJ/mol

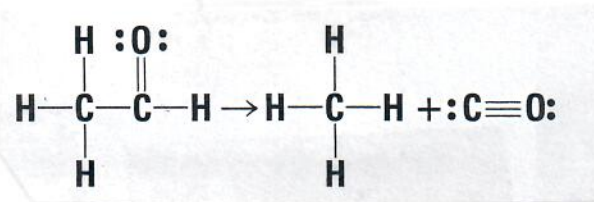
Endo

5. $E_a = 250\ kJ/mol + 200\ kJ/mol = 450\ kJ/mol$

*Answer:* The direct reaction has an activation energy of 450 kJ/mol.



6)




← Balanced

(1 molecule of each)

R: 1 C-C Bond × 1 molecule = 1 BOND | $E_{C-C}$ = 347 KJ/mole
4 C-H Bonds × 1 molecule = 4 BOND | $E_{C-H}$ = 413 KJ/mole
1 C=O Bond × 1 molecule = 1 BOND | $E_{C=O}$ = 745 KJ/mole

P: 4 C-H Bonds × 1 molecule = 4 BOND | $E_{C-H}$ = 413 KJ/mole
1 C≡O Bond × 1 molecule = 1 BOND | $E_{C\equiv O}$ = 1077 KJ/mole

R: $\Delta H_{\text{Bonds Broken}} = (1)(347) + (4)(413) + (1)(745) = 2744$ KJ/mole

P: $\Delta H_{\text{Bonds Formed}} = -((4)(413) + (1)(1077)) = -2729$ KJ/mole

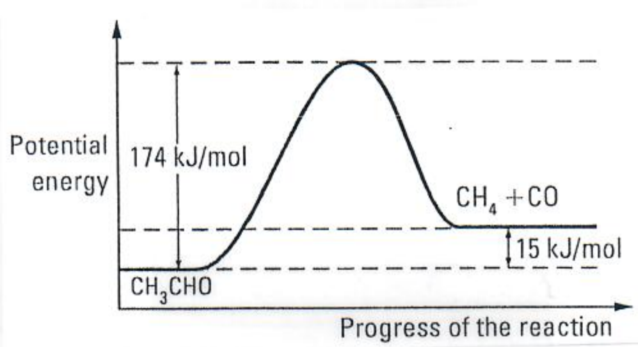
$\Delta H_{\text{Reaction}} = \Delta H_{\text{Bonds Broken}} + \Delta H_{\text{Bonds formed}}$

$= 2744 + (-2729)$

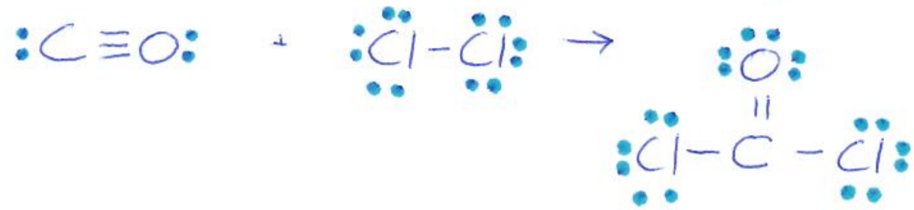
$= 15$ KJ/mol ← Endothermic

Energy Diagram:

$E_A$ = 174 KJ/mol
$\Delta H$ = 15 KJ/mol
Endo



7) $CO + Cl_2 \rightarrow COCl_2$ ← Balanced



(1 molecule of each)

R: 1 C≡O bond × 1 molecule = 1 bond
1 Cl–Cl bond × 1 molecule = 1 bond

P: 1 C=O bond × 1 molecule = 1 bond
2 C–Cl bonds × 1 molecule = 2 bonds

$E_{C\equiv O} = 1077$ KJ/mole
$E_{Cl-Cl} = 243$ KJ/mole
$E_{C=O} = 745$ KJ/mole
$E_{C-Cl} = 397$ KJ/mole

R: $\Delta H_{\text{Bonds Broken}} = (1)(1077) + (1)(243) = 1320$ KJ/mole

P: $\Delta H_{\text{Bonds formed}} = -\left((1)(745) + (2)(397)\right) = -1539$ KJ/mole

$\Delta H_{\text{Reaction}} = \Delta H_{\text{Bonds Broken}} + \Delta H_{\text{Bonds formed}}$
$= 1320 + (-1539)$
$= -219$ KJ/mol ← EXO

Energy Diagram:

$E_A = 135$ KJ/mol
$\Delta H = -219$ KJ/mole
EXOTHERMIC