Managing Chemical Processes Test SOLUTIONS

1.

(a) The catalyst provides an alternative reaction pathway with lower activation energy. This increases the productivity of collisions, therefore increasing the number of successful collisions per unit of time.

(b)(i) The slope is steeper for temperature A.

(ii) The reaction has reached equilibrium.

(c) High pressure creates a high concentration of gas (more reactants per volume). This increases the chance of collision between reactant particles, therefore increasing the rate of reaction.

2. (a)(i)(1) **C**

(2) For productive collisions, the particles must collide with sufficient energy to activate. Heat provides energy for the particles to move quickly enough for this to occur.

(3) Since the reaction is exothermic it will release more heat than it absorbs. This energy allows the reaction to continue.

(b)(i) water, air

(ii) +4

(iii) $NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

(iv) NO_2 is a reactant in the process, so if NO_2 is lost the manufacturer will need to produce more which will decrease profit.

3.

(a) Crushing the ore decreases the particle size which increases the surface area available for reaction. This increases the frequency of successful collisions, therefore increasing reaction rate.

(b) O_2

4. (a) The forward and back reactions are occurring at the same rate.

(b) (i) III. Increasing temperature increases rate of reaction, hence equilibrium is achieved more quickly. Since the reaction is exothermic, the equilibrium shifts to oppose the change, hence the reaction occurs to decrease temperature, that is, to the left. Thus there is more A present at equilibrium.

(ii) II. Increasing pressure increases rate of reaction, hence equilibrium is achieved more quickly. The equilibrium will shift to oppose the change (decrease the moles of gas) so the reaction occurs to the right. Thus there is less A present at equilibrium.

5. (a)

	Cl_2	2NO	2NOCl
Initial moles	0	0	1.000
Change	+0.056	+0.112	-0.112
Final	0.056	0.112	0.888

Cl_2: C = n/V = 0.056/2.00 = 0.028 mol L^{-1}
NO: C = n/V = 0.112/2.00 = 0.056 mol L^{-1}
NOCl: C = n/V = 0.888/2.00 = 0.444 mol L^{-1}

(b)(i) $$K_C = \frac{[\text{NOCl}]^2}{[\text{Cl}_2][\text{NO}]^2} = \frac{0.354^2}{0.024 \times 0.048^2} = 2.3 \times 10^3$$

(ii) The equilibrium constant will decrease.

(c)(i) A is NO, B is Cl_2, C is NOCl

(ii) The temperature was increased. A net reaction then occurred in the backward (endothermic) direction to absorb the energy provided by the temperature increase. This converted products into reactants.

6.

(a) $$\frac{[\text{SO}_3]^2}{[\text{O}_2][\text{SO}_2]^2}$$

(b)(i) Yield will decrease.

(ii) Increased temperature favoured the backward reaction. According to LCP the net reaction is in the direction that opposes the change, so backward reaction must absorb energy (endothermic). Therefore the forward reaction is exothermic.

(c) $$C_{SO_2} = \frac{n}{V} = \frac{0.215}{0.500} = 0.430 \text{ mol/L}$$

$$C_{O_2} = \frac{n}{V} = \frac{0.599}{0.500} = 1.20 \text{ mol/L}$$

At equilibrium, $K_C = \dfrac{[\text{SO}_3]^2}{[\text{O}_2][\text{SO}_2]^2}$

$$\therefore [\text{SO}_3] = \sqrt{K_C \times [\text{O}_2][\text{SO}_2]^2} = \sqrt{0.260 \times 1.20 \times 0.430^2} = 0.240 \text{ mol/L}$$

$$n = C \times V = 0.240 \times 0.500 = 0.120 \text{ mol}$$

(d) (6 marks of information, 2 marks for communication)

Using high pressure will increase reaction rate and increase yield. The reaction rate is increased because the higher pressure increases the moles of gas per volume, therefore higher frequency of collisions, leading to more successful collisions per time. The yield is increased because there are more molecules of gas reactants than products, and increased pressure favours the net reaction direction which decreases molecules of gas.

A manufacturer may choose to use moderate pressure if the profit benefits of increased reaction rate and yield are outweighed by the costs or safety measures required to run the reaction at high pressure.