IB Chemistry II Paper 1 Practice Problems – Topics 6/16 and 7/17

1. For the following reaction $K_c = 1.0 \times 10^{-5}$ at 30 °C.

   $2\text{NOCl}(g) \rightleftharpoons 2\text{NO}(g) + \text{Cl}_2(g)$

   Which relationship is correct at equilibrium at this temperature?
   A. The concentration of NO equals the concentration of NOCl.
   B. The concentration of NOCl is double the concentration of Cl$_2$.
   C. The concentration of NOCl is much greater than the concentration of Cl$_2$.
   D. The concentration of NO is much greater than the concentration of NOCl.

2. The reaction below represents the Haber process for the industrial production of ammonia.

   $\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)$

   $\Delta H^\circ = -92$ kJ

   The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important.

   Which statement is correct?
   A. A higher temperature would ensure higher yield and a faster rate.
   B. A lower pressure would ensure a higher yield at a lower cost.
   C. A lower temperature would ensure a higher yield and a faster rate.
   D. A higher pressure would ensure a higher yield at a higher cost.

3. Which statement is correct for the equilibrium $\text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{O}(g)$ in a closed system at 100 °C?

   A. All the H$_2$O(l) molecules have been converted to H$_2$O(g).
   B. The rate of the forward reaction is greater than the rate of the reverse reaction.
   C. The rate of the forward reaction is less than the rate of the reverse reaction.
   D. The pressure remains constant.

4. 0.50 mol of I$_2$(g) and 0.50 mol of Br$_2$(g) are placed in a closed flask. The following equilibrium is established.

   $\text{I}_2(g) + \text{Br}_2(g) \rightleftharpoons \text{IBr}(g)$

   The equilibrium mixture contains 0.80 mol of IBr(g). What is the value of $K_c$?

   A. 0.64
   B. 1.3
   C. 2.6
   D. 64

5. What is the effect of an increase of temperature on the yield and the equilibrium constant for the following reaction?

   $2\text{H}_2(g) + \text{CO}(g) \rightleftharpoons \text{CH}_3\text{OH}(l)$

   $\Delta H^\circ = -128$ kJ

<table>
<thead>
<tr>
<th>Yield</th>
<th>Equilibrium constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Increases</td>
<td>Increases</td>
</tr>
<tr>
<td>B. Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>C. Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>D. Decreases</td>
<td>Decreases</td>
</tr>
</tbody>
</table>

6. Which statements about a liquid are correct?
I. When the temperature of a liquid in a closed container increases, its vapour pressure increases.

II. When the pressure on a liquid increases, its boiling point increases.

III. When the pressure on a liquid increases, its vapour pressure increases.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

7. Consider the following equilibrium reaction.

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]

\[ \Delta H^\circ = -197 \text{ kJ} \]

Which change in conditions will increase the amount of SO\(_3\) present when equilibrium is re-established?

A. Decreasing the concentration of SO\(_2\)
B. Increasing the volume
C. Decreasing the temperature
D. Adding a catalyst

8. Which statements describe the action of a catalyst?

I. It does not alter the \( \Delta H \) for a reaction.
II. It increases the \( E_a \) for the reaction.
III. It alters the mechanism (pathway) of a reaction.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

9. At 25 °C, 200 cm\(^3\) of 1.0 mol dm\(^{-3}\) nitric acid is added to 5.0 g of magnesiu...
D. \[ \text{rate} = k[\text{NO}]^2 [\text{N}_2\text{O}_2]^2 [\text{H}_2] \]

11. The Haber process uses an iron catalyst to convert hydrogen gas, \( \text{H}_2(\text{g}) \), and nitrogen gas, \( \text{N}_2(\text{g}) \), to ammonia gas, \( \text{NH}_3(\text{g}) \).

\[ 3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

Which statements are correct for this equilibrium system?

I. The iron catalyst increases the rates of the forward and reverse reactions equally.

II. The iron catalyst does not affect the value of the equilibrium constant, \( K_c \).

III. The iron catalyst increases the yield of ammonia gas, \( \text{NH}_3(\text{g}) \).

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

12. Which of the following can increase the rate of a chemical reaction?

I. Increasing the temperature

II. Adding a catalyst

III. Increasing the concentration of reactants

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. The following data were obtained for the reaction between gases A and B.

Which relationship represents the rate expression for the reaction?

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Initial [A] / mol dm(^{-3})</th>
<th>Initial [B] / mol dm(^{-3})</th>
<th>Initial rate / mol dm(^{-3}) min(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1.0 \times 10^{-3})</td>
<td>(1.0 \times 10^{-3})</td>
<td>(2.0 \times 10^{-4})</td>
</tr>
<tr>
<td>2</td>
<td>(2.0 \times 10^{-3})</td>
<td>(1.0 \times 10^{-3})</td>
<td>(2.0 \times 10^{-4})</td>
</tr>
<tr>
<td>3</td>
<td>(2.0 \times 10^{-3})</td>
<td>(2.0 \times 10^{-3})</td>
<td>(4.0 \times 10^{-4})</td>
</tr>
</tbody>
</table>

A. \[ \text{rate} = k[B]^2 \]

B. \[ \text{rate} = k[A]^2 \]

C. \[ \text{rate} = k[A] \]

D. \[ \text{rate} = k[B] \]

14. Which changes increase the rate of the reaction below?

\[ \text{C}_4\text{H}_{10}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{C}_4\text{H}_9\text{Cl}(\text{l}) + \text{HCl}(\text{g}) \]

A. I and II only

B. I and III only

C. II and III only

D. I, II and III