

# Chemical Equilibria and Le Chatelier's Principle

## Question Paper 10

Level	A Level
Subject	Chemistry
Exam Board	AQA
Module	3.1 Physical Chemistry
Topic	3.1.6 Chemical Equilibria + Le Chatelier +Kc
Sub-Topic	3.1.6.1 Chemical Equilibria and Le Chatelier's Principle
Booklet	Question Paper 10

**Time Allowed:** 22 minutes

**Score:** /22

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	75%	70%	60%	55%	50%	<50%

**Q1.**A weak acid HA dissociates in aqueous solution as shown below

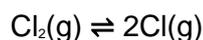


Which one of the following changes will result in a decrease in the pH of an aqueous solution of the acid?

- A** addition of a little aqueous sodium hydroxide solution
- B** raising the temperature of the solution
- C** dissolving a little of the sodium salt, NaA, in the solution
- D** adding a platinum catalyst to the solution

**(Total 1 mark)**

**Q2.**A sample of chlorine gas was sealed in a tube, heated and an equilibrium was established.

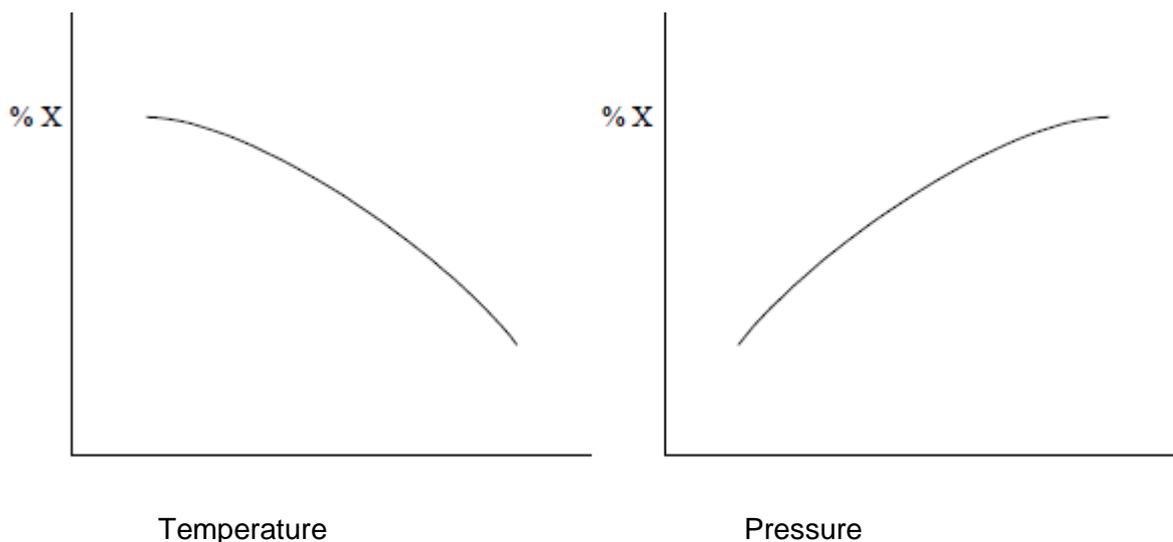


Which one of the following is **not** true?

- A** The concentration of chlorine atoms remains the same when a catalyst is added to the tube.
- B** Increase in temperature causes an increase in the concentration of chlorine atoms.
- C** Increase in pressure causes an increase in the concentration of chlorine atoms relative to chlorine molecules.
- D** Addition of more chlorine gas to the tube causes an increase in the concentration of chlorine atoms.

**(Total 1 mark)**

**Q3.**A compound **X** is formed during a gas phase reaction. The graphs below show how the percentage of a compound **X** present at equilibrium varies with temperature and pressure.

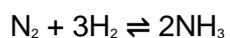


Which one of the following statements concerning the formation of **X** is correct?

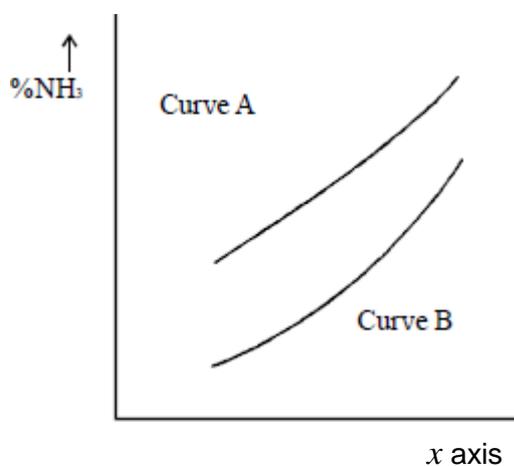
- A** The reaction is exothermic and involves a decrease in the number of moles of gas.
- B** The reaction is exothermic and involves no change in the number of moles of gas.
- C** The reaction is exothermic and involves an increase in the number of moles of gas.
- D** The reaction is endothermic and involves a decrease in the number of moles of gas.

(Total 1 mark)

**Q4.** The graph shows the equilibrium percentage of ammonia present during the formation of ammonia by the Haber process:



$$\Delta H = -92 \text{ kJ mol}^{-1}$$

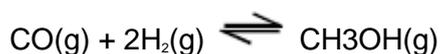


Which one of the following are correct labels for the graph?

	<i>x</i> axis	Curve A	Curve B
A	temperature	high pressure	low pressure
B	temperature	low pressure	high pressure
C	pressure	high temperature	low temperature
D	pressure	low temperature	high temperature

(Total 1 mark)

**Q5.** The following information concerns the equilibrium gas-phase synthesis of methanol.



At equilibrium, when the temperature is 68 °C, the total pressure is 1.70 MPa. The number of moles of CO, H<sub>2</sub> and CH<sub>3</sub>OH present are 0.160, 0.320 and 0.180, respectively.

Thermodynamic data are given below.

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
CO(g)	-110	198
H <sub>2</sub> (g)	0	131
CH <sub>3</sub> OH(g)	-201	240

Which one of the following statements applies to this equilibrium?

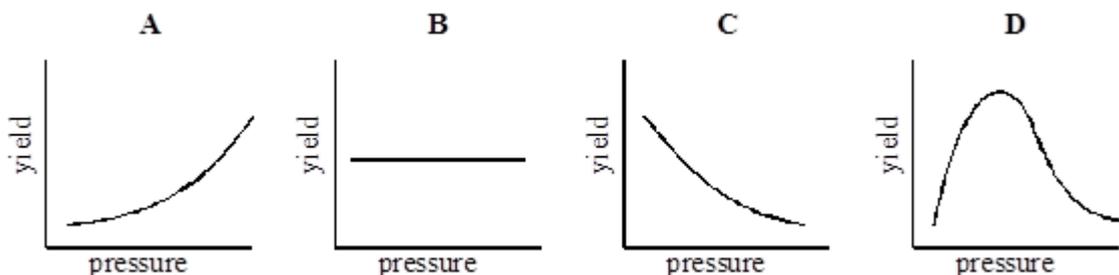
- A The value of  $K_p$  increases if the temperature is raised.
- B The value of  $K_p$  increases if the pressure is raised.
- C The yield of methanol decreases if the temperature is lowered.
- D The yield of methanol decreases if the pressure is lowered.

(Total 1 mark)

**Q6.** Phosphorus(V) chloride decomposes at high temperatures into phosphorus(III) chloride and chlorine according to the equation.



Which one of the graphs best represents the variation with pressure of the yield of chlorine at equilibrium?



(Total 1 mark)

**Q7.** (a) Hydrogen used in the Haber Process is produced in the following dynamic equilibrium reaction.



(i) In terms of rates and of concentrations, what does the term *dynamic equilibrium* mean?

Rates .....

Concentrations .....

(ii) State how an increase in pressure will affect the equilibrium yield of hydrogen. Explain your answer.

Equilibrium yield .....

Explanation .....

(iii) The equilibrium yield of hydrogen is reduced when the reaction is carried out at a lower temperature. What can be deduced about the enthalpy change in this reaction?

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(iv) Explain why the equilibrium yield is unchanged when a catalyst is introduced.

.....  
.....

(8)

(b) Ammonia is produced in the Haber Process according to the following equation.



Typical operating conditions are 450 °C and 20 MPa (200 bar).

(i) Explain why 450 °C is a compromise temperature.

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(ii) Explain why 20 MPa is a compromise pressure.

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.....  
.....

(6)

(Total 14 marks)

**Q8.**The equilibrium constant,  $K_c$ , for a reaction which leads to ozone ( $\text{O}_3$ ) formation is

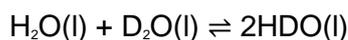
$$K_c = \frac{[\text{N}_2][\text{O}_3]^2}{[\text{NO}]^2[\text{O}_2]^2}$$

More ozone is formed as the temperature rises. Which one of the following is true at equilibrium?

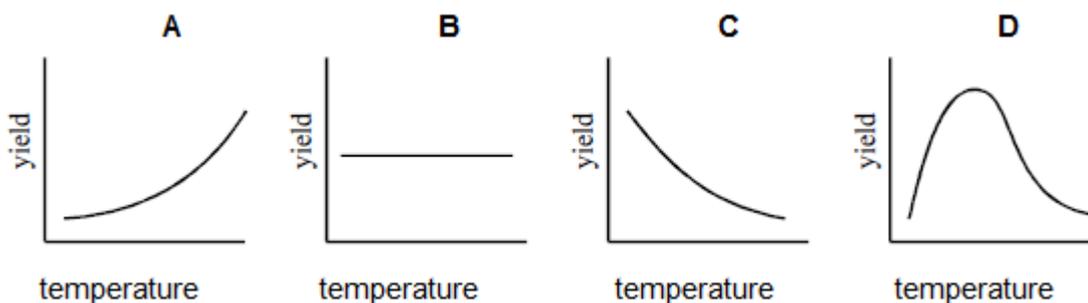
- A When ozone molecules collide with nitrogen they may form nitrogen monoxide.
- B The enthalpy change for the reaction has a negative sign.
- C Less ozone is formed at high pressure.
- D At a fixed temperature, the magnitude of  $K_c$  increases as the concentration of NO decreases.

(Total 1 mark)

Q9. Normal water and heavy water react together to form isotopically mixed water according to the equation



The standard enthalpy of formation of  $\text{H}_2\text{O}(\text{l})$  is  $-286 \text{ kJ mol}^{-1}$ , that of  $\text{D}_2\text{O}(\text{l})$  is  $-294 \text{ kJ mol}^{-1}$ , and that of  $\text{HDO}(\text{l})$  is  $-290 \text{ kJ mol}^{-1}$ . Which one of the following best represents the variation with temperature of the yield of HDO at equilibrium?



(Total 1 mark)