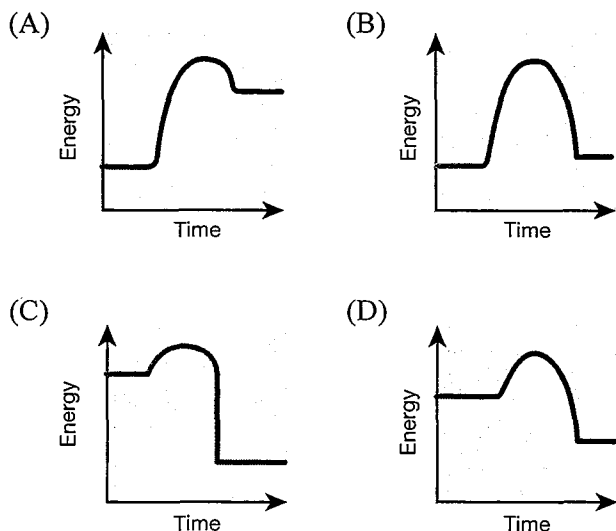


14 Revision of Chemical Equilibrium

Use these questions to help you revise the work covered so far and find any weaknesses in your knowledge or understanding. Answer the questions like a test. If you have any errors and you do not understand why your answers are not correct, then you should discuss those questions with your teacher.

- Which of the following is an example of an exothermic chemical reaction?
 - Decomposition of calcium carbonate.
 - Combustion of sodium metal.
 - Fractional distillation of petroleum.
 - Condensation of water.
- For which of the following reactions would decreasing the pressure cause an increase in the yield of product?
 - $A(g) + B(g) \rightleftharpoons C(g) + D(g)$
 - $A(aq) + B(aq) \rightleftharpoons C(aq) + D(aq)$
 - $A(aq) + B(g) \rightleftharpoons C(g) + D(g)$
 - $A(g) + B(g) \rightleftharpoons C(g) + D(aq)$
- In a system at equilibrium:
 - The rate of the forward reaction equals the rate of the reverse reaction.
 - The concentration of reactants equals the concentration of products.
 - All concentrations are equal.
 - The addition of a catalyst increases the yield of a product.
- Consider the four energy profiles shown below. Identify the one that is exothermic and most likely to go to completion.

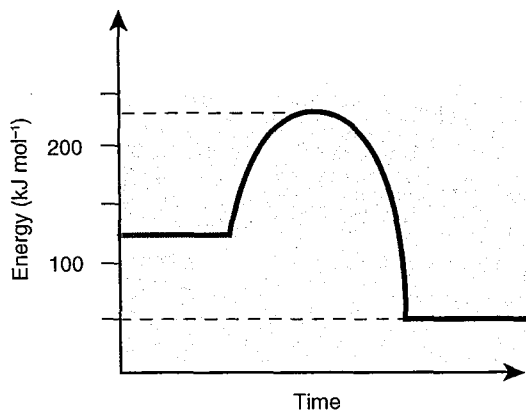


- The rates of many chemical reactions are initially fast and then slow down as reactants are used up. Which graph best illustrates this?
 -
 -
 -
 -

- Which of the following represents a system at equilibrium?
 - A sealed can of soft drink.
 - Year 12 in the playground at lunch time.
 - The Earth's water cycle.
 - An open can of soft drink.
- An equilibrium will not be established if:
 - Water forms.
 - A gas escapes.
 - A precipitate forms.
 - Temperature is kept constant.
- When catalysts are used in a reversible reaction:
 - More product is formed.
 - The forward reaction rate increases.
 - Equilibrium is reached sooner.
 - There is no change.
- A reaction can be seen to be at equilibrium when:
 - There is no macroscopic change.
 - No gas is produced.
 - No precipitate forms.
 - The catalyst has been used up.
- Consider the reaction:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$
 Which one of the following statements is correct about this system when it has reached equilibrium?
 - The concentration of reactants equals the concentration of products.
 - The concentrations of all reactants and products remain constant.
 - The concentrations of all reactants and products are equal.
 - The concentrations of carbon monoxide and water are equal but different from the concentrations of carbon dioxide and hydrogen.

11. The concentrations of reactants and products in a system at equilibrium depend on:
- The initial concentrations.
 - The equilibrium position.
 - The relative chemical energies of the reactants and products.
 - All of the above.
12. The diagram shows an energy profile for a combustion reaction.



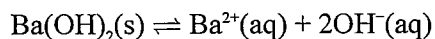
This diagram represents:

- An endothermic reaction.
 - A reaction with activation energy equal to 230 kJ mol^{-1} .
 - A reaction with an enthalpy change of 180 kJ mol^{-1} .
 - An exothermic reaction with activation energy of 105 kJ mol^{-1} .
13. For the equilibrium reaction:
 $\text{A(g)} + \text{B(g)} \rightleftharpoons \text{C(aq)} + \text{D(g)}$
 the reaction in the forward direction (as written) is exothermic. Which of the following changes would cause the equilibrium position to move to the left?
- Increase the concentration of A.
 - Increase the concentration of D.
 - Remove D as it forms.
 - Increase the pressure.
14. In the Haber-Bosch process, the reactants are:
- N_2 and H_2
 - N_2 and NH_3
 - NO_3^- and NH_3
 - H_2 and NH_3
15. Today the main source of nitrogen for the Haber-Bosch process is:
- The electrolysis of water.
 - Fertiliser.
 - Nitrates extracted from soil.
 - Atmospheric nitrogen.

16. In the Haber-Bosch process, in order to increase the yield, the reaction pressure is increased to about 300 atmospheres. This works because:
- There are more molecules of hydrogen than molecules of nitrogen or ammonia.
 - There are fewer molecules of gaseous products than gaseous reactants.
 - There are more molecules of gaseous products than gaseous reactants.
 - Increasing pressure causes more collisions with the sides of the container.
17. Which of the following is a suitable catalyst for the Haber-Bosch process?
- Concentrated sulfuric acid.
 - Alumina silica gel.
 - Iron oxide.
 - Transition metals.
18. For maximum yield in the Haber-Bosch process:
- A very low temperature is maintained, as the reaction is exothermic and a high temperature would decrease yield.
 - A very high temperature is maintained to increase the number of collisions and hence the reaction rate.
 - A moderate temperature is maintained as a compromise between A and B.
 - The temperature is allowed to fluctuate so Le Châtelier's principle can take effect.
19. Which gas makes up approximately 80% of the atmosphere?
- Nitrogen.
 - Oxygen.
 - Carbon dioxide.
 - Water vapour.
20. Equilibrium constants (K) are useful for determining the strength of acids. Which of the following statements is correct?
- A high K value indicates an acid is weak.
 - Only strong acids have a K value.
 - The weaker an acid, the lower the K value.
 - Concentrated acids have high K values.
21. Which of the following does not alter the equilibrium position of a system at equilibrium?
- Changing the temperature of the system.
 - Adding more of one reaction species.
 - Adding a catalyst to the system.
 - Increasing pressure by decreasing volume.
22. Which alternative provides the equilibrium expression for the following reaction?
 $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
- $\frac{[\text{HI}(\text{g})]^2}{[\text{H}_2(\text{g})][\text{I}_2(\text{g})]}$
 - $\frac{\text{HI}^2(\text{g})}{\text{H}_2(\text{g}) \times \text{I}_2(\text{g})}$
 - $\frac{[\text{H}_2(\text{g})][\text{I}_2(\text{g})]}{[\text{HI}(\text{g})]^2}$
 - $\frac{[\text{HI}(\text{g})]}{[\text{H}_2(\text{g})][\text{I}_2(\text{g})]}$

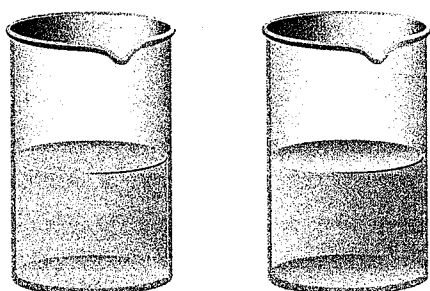
23. The value of the equilibrium constant for an equilibrium system can be changed by changing the:
- (A) Temperature. (B) Pressure.
(C) Concentration. (D) Volume.

24. Barium hydroxide ($\text{Ba}(\text{OH})_2$) is slightly soluble in water.

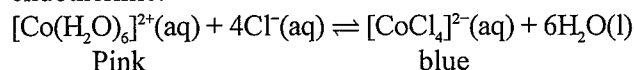


A sample of barium hydroxide will completely dissolve when:

- (A) More $\text{Ba}(\text{OH})_2$ is added.
(B) The solution is alkaline.
(C) The solution is acidic.
(D) Pressure is increased.
25. Cobalt chloride exists as two different complex ions, $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ which is pink and $[\text{CoCl}_4]^{2-}$ which is blue.



In solution, both cobalt chloride complexes exist together in equilibrium. The forward reaction is endothermic.



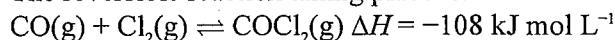
This equilibrium can be disturbed by changing the temperature or the chloride ion concentration.

To turn the colour blue you would:

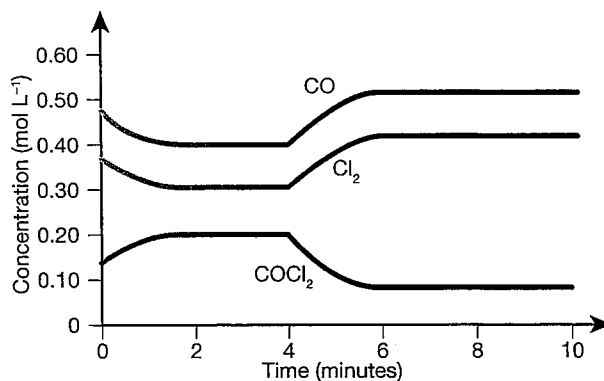
- (A) Add dilute hydrochloric acid or place the container in a hot water bath.
(B) Dilute the solution by adding water and place the container in an ice water bath.
(C) Place the container in the refrigerator.
(D) Add a chemical which will react with cobalt chloride to form a blue salt.

26. Phosgene gas, carbon dioxide and chlorine form an equilibrium mixture in a sealed container.

The reversible reaction taking place is:



The graph shows equilibrium being reached, then disturbed and finally a new equilibrium position being reached.



At time 4 minutes, the equilibrium system was disturbed by:

- (A) Extracting some COCl_2 .
(B) Adding more CO and Cl_2 .
(C) Adding a catalyst.
(D) Heating the system.
27. State whether each of the following statements is true or false and justify your decision.
- (a) The statement, 'The reactions are at equilibrium', means that the reaction is finished, it is stable and it will not react any more unless something is added.
(b) When a system is in chemical equilibrium, no more change takes place.

14 Revision of Chemical Equilibrium

- | | | | | |
|-------|-------|-------|-------|-------|
| 1. B | 2. C | 3. A | 4. C | 5. C |
| 6. A | 7. B | 8. C | 9. A | 10. B |
| 11. D | 12. D | 13. B | 14. A | 15. D |
| 16. B | 17. C | 18. C | 19. A | 20. C |
| 21. C | 22. A | 23. A | 24. C | 25. A |
| 26. D | | | | |

27. (a) False. An equilibrium reaction is not finished or stable – the forward and reverse reactions are both continuing, but they are occurring at the same rate, at a submicroscopic level, so no change can be observed.
- (b) False. You cannot observe (e.g. see or smell) any change, but changes are constantly happening between atoms and molecules – they are just too small for us to see them changing. It looks like there is no change happening because reactants (and also products) are breaking up and re-forming at the same rate.