Big Chem Problem Set

KINETICS AND EQUILIBRIUM

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1. According to collision theory, in terms of effective collisions, what are the requirements for a reaction to occur?
2. Before dissolving salt in water [$NaCl_{(s)} \rightarrow NaCl_{(aq)}$], the salt is crushed. What effect does crushing have on the rate of solution?
3. Consider the reaction: $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O2_{(g)}$, where MnO_2 acts as a catalyst
   (a) As the temperature increases from 120°C to 150°C, what happens to the rate of the reaction?
   (b) In terms of collision theory, why does raising the temperature effect the reaction rate?
   (c) What is the function of the MnO_2? What effect does it have on the reaction rate?
4. What could be done to speed up a reaction between carbon dioxide gas [$CO2_{(g)}$] and water [$H_2O_{(liq)}$] to form carbonic acid [$H_2CO_{3(aq)}$]?
5. Based on collision theory, explain how heat and concentration effect reaction rates.
6. Based on Reference Table I, when 2.00 moles of $NaOH_{(s)}$ dissolve in water, how much energy is exchanged? Is it absorbed or released by the NaOH? Does the water temperature increase or decrease?
7. Based on Reference Table I, when 3.4 moles of water decompose to form hydrogen and oxygen gas, how much energy is required?
8. Why is it necessary to supply energy in the form of a spark to ignite the gasoline in an automobile engine if gasoline releases energy when it burns?
9. What is an activated complex?
10. How does the potential energy of the activated complex compare to that of the reactant or the product?
11. Base your answers to the following questions on the 'PE Diagram: Endothermic Reaction' from your notes:
    (a) Which has the highest energy–the reactants, the products, or the activated complex?
    (b) Which has the lowest energy–the reactants, the products, or the activated complex?
    (c) If the reactants have a potential energy of 10.2 kJ/mol and the products have a potential energy of 15.7 kJ/mol, what is delta H?
    (d) What effect do catalysts have on the change in H?
    (e) Catalysts are used to speed up chemical reactions. Based on the graph above, how do they do this?
12. Dry ice is solid carbon dioxide [$CO_{2(s)}$]. Carbon dioxide occurs naturally as a gas in the atmosphere [$CO_{2(g)}$]. Which form of carbon dioxide has higher entropy? What happens to the enthalpy during this reaction. What happens to the entropy during this reaction.
13. For each of the following, the products have higher entropy than the reactants. Explain why:
    (a) $H_2O_{(s)} \rightarrow H_2O_{(liq)}$
    (b) $2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$ + Energy
    (c) $I_{2(s)} \rightarrow I_{2(g)}$
14. A sealed jar of water is left in the sun. How can you tell it is in phase equilibrium?
15. A liquid in a soppered flask is allowed to stand at constant temperature until the liquid level in the flask remains constant. Describe the rate of condensation and evaporation inside the flask. Justify your answer with evidence.
16. In terms or reactants and products, how can you tell when a chemical reaction is in equilibrium?

17. Given the reaction at equilibrium: $N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$. If the pressure is increased at constant temperature, the number of moles of what substance will increase?

18. Given the reaction at equilibrium: $4\ HCl_{(g)} + O2_{(g)} \rightarrow 2\ Cl_{2(g)} + 2\ H_2O_{(g)}$. If the pressure on the system is increased, what effect would this have on the concentration of $Cl_{2(g)}$?

19. Given the reaction at equilibrium: $A_{(g)} + B_{(g)} \rightarrow C_{(g)} + D_{(g)}$, What effect will the addition of a catalyst have on the system?

20. What effect will the addition of a catalyst have on the rate of forward or reverse reactions of a system in equlibrium?

21. Choose all of the factors of reaction that will have the required effect from the following list: concentration, pressure, temperature, catalyst.
(a) Given the reaction at equilibrium: $2\ SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)} + 44$ kcal, Which factors of the reaction can be changed that will increase the concentration of $SO_{3(g)}$?
(b) Given the reaction at equilibrium: $N_{2(g)} + O_{2(g)} \leftrightarrow 2NO_{(g)}$. If the temperature remains constant and the pressure increases, what will happen to the number of moles of $NO_{(g)}$?

22. Base your answers to a and b on the following reaction: $2\ CI_{2(g)} + 2H_2O_{(g)} \rightarrow 4HCl_{(g)} + O_{2(g)}$, delta H = +27 kcal.
(a) If O_2 is added to the system at a constant pressure and temperature, what will happen to the number of moles of HCl?
(b) If the temperature of the system is increased at a constant pressure, what will happen to the rate of the forward reaction?

23. Given the reaction at equilibrium: $N_{2(g)} + O_{2(g)} + 21.6$ kcal $\rightarrow 2NO_{(g)}$, list all the factors that would cause the equilibrium to shift right.

24. What effect would an increase in pressure have on equilibrium?
(a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
(b) $4H_{2(g)} + CS_{2(g)} \rightarrow CH_{4(g)} + 2H_2S_{(g)}$
(c) $CO_{(g)} + H_2O_{(g)} \rightarrow H_{2(g)} + CO_{2(g)}$
(d) $H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$
(e) $PCl_{5(g)} \rightarrow PCl_{3(g)} + Cl_{2(g)}$

25. For each of the following, what effect would an increase in temperature have on equilibrium:
(a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)})H = -92$ kJ
(b) $C_{(s)} + H_2O_{(g)} + \text{heat} \rightarrow CO_{(g)} + H_{2(g)}$
(c) $PCl_{3(g)} + Cl_{2(g)} \rightarrow PCl_{5(g)} + \text{heat}$
(d) $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)} + \text{heat}$
(e) $H_2O_{(liq)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}\ )H = 55.8$ kJ

26. For the reaction, $H_{2(g)} + I_{2(g)}) \rightarrow 2HI_{(g)}$ [delta H = 52.7 kJ], what effect will each of the following have on equilibrium?
(a) Addition of $H_{2(g)}$
(b) Removal of $I_{2(g)}$
(c) Increase in temperature
(d) Increase in pressure
(e) Addition of $HI_{(g)}$