

Choose the **best** answer and mark the letter representing it on the answer sheet. You may write on this exam.

**OMIT any 3 questions and mark them on answer sheet.**

- The conjugate base of  $\text{NH}_3$  is: a.  $\text{NH}_4^+$  b.  $\text{NH}_4\text{OH}$  c.  $\text{NH}_2^-$  d.  $\text{OH}^-$
- What is the pH of a buffer with a  $[\text{H}^+]$  of  $6.4 \times 10^{-7}$ ?  
a. 6.2 b. 7.0 c. 7.8 d. 2.0
- What is the molarity of a  $\text{Ba}(\text{OH})_2$  solution with a pH of 12.5?  
a. 0.0316 b. 0.0158 c.  $3.16 \times 10^{-13}$
- What is the  $K_a$  for weak acid, HB, if a 1.0 M solution has a pH of 3.0?  
a.  $1.0 \times 10^{-6}$  b.  $1.0 \times 10^{-3}$  c. 6.0 d. 3.0
- The  $K_a$  for HBr is:  
a. equal to the molarity of the acid.  
b. equal to the  $-\log [\text{H}^+]$   
c. extremely small d. extremely large

**Use the following information for questions 6 through 12. Acids HX and HY and HZ have  $K_a$ s of  $1.0 \times 10^{-5}$ ,  $1.0 \times 10^{-7}$  and  $1.0 \times 10^{-9}$  respectively. Indicator HIn is blue and  $\text{In}^-$  is yellow.  $\text{p}K_a$  for HIn is 6.0**

- Which 1 M acid solution has the lowest pH? a. HX b. HY c. HZ
- Which acid would have the highest pH at the equivalence point in titration with NaOH? a. HX b. HY c. HZ
- What is the  $K_b$  for  $\text{X}^-$ ?  
a.  $1.0 \times 10^{-9}$  b.  $1.0 \times 10^{-14}$   
c.  $1.0 \times 10^{-19}$  d.  $1.0 \times 10^{-7}$
- If 50.0 mL of 0.100 M HY and 50.0 mL of 0.050 M NaOH were mixed, the pH of the mixture would be:  
a. less than 7.0. b. greater than 7.0.  
c. equal to 7.0. d. not determinable from this data.
- If 50.0 mL of 0.050 M HX and 50.0 mL of 0.100 M NaOH were mixed the pH of the mixture would be:  
a. equal to 7.0. b. about 12.4  
c. a little above 7.0. d. a little below 7.0.
- What could be added to a solution of NaX to prepare a buffer?  
A. NaOH B. HClC. HX D. LiX  
a. B, C, D b. B c. D d. B, C
- What color would indicator HIn be in an aqueous 1.0 M HY solution? a. yellow b. green c. blue
- When sodium fluoride, NaF is dissolved in water, the resulting solution is \_\_\_\_\_ and the appropriate equation is \_\_\_\_\_.  
a. acidic,  $\text{Na}^+(\text{aq}) + \text{H}_2\text{O}(\text{l}) \Rightarrow \text{NaOH}(\text{aq}) + \text{H}^+(\text{aq})$   
b. basic,  $\text{F}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \Rightarrow \text{HF}(\text{aq}) + \text{OH}^-(\text{aq})$   
c. acidic,  $\text{F}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \Rightarrow \text{FOH}^{2-}(\text{aq}) + \text{H}^+(\text{aq})$   
d. neutral, there is no reaction.
- Given that  $K_a$  for HCN is  $5.8 \times 10^{-10}$  and  $K_b$  for  $\text{NH}_3$  is  $1.8 \times 10^{-5}$ , a solution of  $\text{NH}_4\text{CN}$  in water would be:  
a. basic. b. neutral. c. acidic. d. amphiprotic.

15. If the molar solubility of  $\text{Ag}_2\text{CrO}_4$  is  $6.3 \times 10^{-5}$ , the  $K_{\text{sp}}$  for this compound is:

- a.  $2.5 \times 10^{-13}$ .      b.  $7.9 \times 10^{-9}$ .  
c.  $1.0 \times 10^{-12}$ .      d.  $4.0 \times 10^{-9}$ .

16. What is the molar solubility of  $\text{BaSO}_4$  if its  $K_{\text{sp}}$  is  $1.0 \times 10^{-10}$ ?

- a.  $1.0 \times 10^{-20}$       b.  $1.0 \times 10^{-5}$   
c.  $5.0 \times 10^{-6}$       d.  $2.0 \times 10^{-5}$

17. Relate the solubility (s) of slightly soluble  $\text{Mg}(\text{OH})_2$  to its  $K_{\text{sp}}$ .

- a.  $K_{\text{sp}} = s^2$     b.  $K_{\text{sp}} = 2s^2$     c.  $K_{\text{sp}} = 2s^3$     d.  $K_{\text{sp}} = 4s^3$

18. Which salt(s) would be soluble in  $\text{HNO}_3$  solution?

- A.  $\text{AgC}_2\text{H}_3\text{O}_2$       B.  $\text{Ca}_3(\text{PO}_4)_2$     C.  $\text{ZnS}$       D.  $\text{PbI}_2$   
a. A, C      b. D      c. B, C      d. A, B, C

19. Strontium sulfate ( $\text{SrSO}_4$ ) is slightly soluble in water. In which of these aqueous solutions would  $\text{SrSO}_4$  be the LEAST soluble?

- a. 0.1 M  $\text{Na}_2\text{SO}_4$     b. 0.01 M  $\text{K}_2\text{SO}_4$     c. 0.2 M  $\text{KNO}_3$     d. pure water

20. Given:  $K_{\text{sp}}$  of  $\text{PbI}_2 = 8.4 \times 10^{-9}$ ,  $K_{\text{sp}}$  of  $\text{AgI} = 1.0 \times 10^{-16}$ . If solid  $\text{NaI}$  is slowly stirred into a solution which is 0.010 M in  $\text{Pb}^{2+}$  and 0.010 M in  $\text{Ag}^+$ , at what molar concentration of  $\text{I}^-$  will the first precipitate appear?

- a.  $1.0 \times 10^{-16}$       b.  $1.0 \times 10^{-14}$     c.  $8.4 \times 10^{-7}$       d.  $9.1 \times 10^{-4}$

21. A reaction caused the temperature of 28.00 g of water (specific heat,  $4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ ) to rise from 25.00  $^\circ\text{C}$  to 26.48  $^\circ\text{C}$ . What is the value for "q" for this reaction?

- a. -9.62 J    b. -32.kJ    c. -124 J    d. -173 J

22. If "Y" is a state property, then:

- a.  $\Delta Y = Y_{\text{final}} - Y_{\text{initial}}$       b.  $\Delta Y < 0$   
c.  $\Delta Y > 0$       d.  $\Delta Y = Y_{\text{final}}$

23. The specific heat of  $\text{CO}_2(\text{g})$  is  $0.843 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$  and that of  $\text{Cl}_2$  is  $0.478 \text{ g}^{-1} \text{ }^\circ\text{C}^{-1}$ . If the same amount of heat is transferred to equal masses of  $\text{CO}_2(\text{g})$  and  $\text{Cl}_2(\text{g})$  both initially at the same temperature,

- a. the final temperature of both will be the same.  
b. the final temperature of  $\text{CO}_2$  will be greater.  
c. the final temperature of  $\text{Cl}_2$  will be greater.  
d. the final temperature of each will depend on the rate of heating.

24. How many kJ are required to convert 55 g of ethanol (46) from liquid vapor at its boiling point if  $\Delta H_{\text{vap}}$  is 38.5 kJ/mole?

- a. 11.0 kJ    b. 24.9 kJ    c. 46.0 kJ    d. 2120 kJ

25. Determine the  $\Delta H^\circ$  for the reaction,

$\text{NO}(\text{g}) + \text{O}(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$  given the following data.

$2\text{O}_3(\text{g}) \rightleftharpoons 3\text{O}_2$      $\Delta H^\circ = -427 \text{ kJ}$

$2\text{O}_2(\text{g}) \rightleftharpoons 4\text{O}(\text{g})$      $\Delta H^\circ = +990 \text{ kJ}$

$\text{NO}(\text{g}) + \text{O}_3(\text{g}) \rightleftharpoons \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$      $\Delta H^\circ = -199 \text{ kJ}$

- a. -480 kJ    b. -233 kJ    c. -131 kJ    d. +364 kJ

26. Which of the following substances has a heat of formation equal to zero at 25  $^\circ\text{C}$ ?

- a.  $\text{H}_2\text{O}(\text{g})$     b.  $\text{Na}(\text{g})$     c.  $\text{O}_2(\text{g})$     d.  $\text{Cl}_2(\text{l})$

27. Given the thermochemical equation,  $2\text{Cu}_2\text{O}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{CuO}(\text{s})$   $\Delta H^\circ = -292\text{kJ}$ , and that the standard heat of formation of  $\text{CuO}(\text{s})$  is  $-157.3 \text{ kJ/mole}$ . What is the heat of formation of  $\text{Cu}_2\text{O}(\text{s})$ ?

- a. -449.3 kJ/mole                      b. -168.6 kJ/mole  
 c. -134.7 kJ/mole                      d. +134.7 kJ/mole

28. A system absorbs 60 J of heat and at the same time does 50 J of work. What is the change in energy of the system?

- a. -110 J    b. -10 J    c. +10 J    d. +110 J

29. What is the expansion work done by the system when 1.00 mole of liquid bromine vaporizes at its boiling point of 59 °C at 1.00 atm pressure? (1 L-atm = 0.1013 kJ and R = 0.821 L atm/mole K)

- a. -2.76 kJ    b. 0.491 kJ    c. +5.98 kJ    d. +47.8 kJ

30. Which of the following processes is expected to have a negative entropy change?

- a. two gases are mixed    b.  $\text{Br}_2(\text{g}) \rightleftharpoons \text{Br}_2(\text{l})$   
 c.  $2\text{NO}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{O}_2(\text{g})$     d. the sublimation of ice

31. In order for the entropy of a substance to be zero, that substance must be,

- a. a pure element in its standard state.  
 b. in equilibrium with its component elements.  
 c. a completely ordered pure crystal at 0 K.  
 d. an ideal gas.

32. One expression for the second law of thermodynamics would be,

- a. spontaneous reactions always have positive Gibbs free energy changes.  
 b. the entropy of the universe always increases in spontaneous reactions.  
 c. energy is a conserved quantity.  
 d.  $\Delta G = \Delta G^\circ + RT \ln Q$

33. In order for a reaction to be spontaneous at constant T and P, which of the following must be true?

- a.  $\Delta G < 0$     b.  $\Delta H < 0$     c.  $\Delta S > 0$     d.  $\Delta S = 0$

34. For a particular reaction, which of the following would be most greatly affected by a change in the temperature?

- a.  $\Delta H$     b.  $\Delta S$     c.  $\Delta G$     d.  $\Delta H/\Delta S$

35. The reaction,  $\text{CaO}(\text{s}) + \text{SO}_3(\text{g}) \rightleftharpoons \text{CaSO}_4(\text{s})$  has a  $\Delta H^\circ$  of -403 kJ and a  $\Delta S^\circ$  of -190 J/K. When will the reaction be spontaneous?

- a. only in the reverse direction    b. only at low T  
 c. at all temperatures    d. only at high T

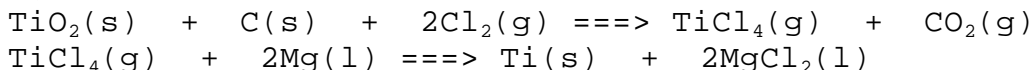
36. The Gibbs free energy of formation of  $\text{NO}_2(\text{g})$  is the free energy change for the reaction:

- a.  $\text{NO}(\text{g}) + 1/2\text{O}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$     b.  $\text{NO}_2(\text{g}) \rightleftharpoons 1/2\text{N}_2(\text{g}) + \text{O}_2(\text{g})$   
 c.  $2\text{O}(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$     d.  $1/2\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$

37. The decomposition of molecular nitrogen given by the reaction,  $\text{N}_2(\text{g}) \rightleftharpoons 2\text{N}(\text{g})$ , is not expected to be spontaneous at 25 °C and 1 atm. Which would be true for this system under these conditions?

- a.  $\Delta G^\circ < 0, K < 1$                       b.  $\Delta G^\circ < 0, K > 1$   
 c.  $\Delta G^\circ > 0, K < 1$                       d.  $\Delta G^\circ > 0, K > 1$

38. Titanium ore ( $\text{TiO}_2$ ) is processed to titanium metal by the following set of reactions:



What substance reduces the Ti (IV)? a. C    b.  $\text{Cl}_2$     c. Mg    d.  $\text{CO}_2$

39. Which reaction describes the formation of slag in a blast

furnace for the production of pig iron?

- a.  $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \implies 2\text{CO}(\text{g})$
- b.  $\text{C}(\text{s}) + \text{O}_2(\text{g}) \implies \text{CO}_2(\text{g})$
- c.  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \implies 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$
- d.  $\text{CaO}(\text{s}) + \text{SiO}_2(\text{s}) \implies \text{CaSiO}_3(\text{l})$

40. The "basic oxygen" process is used to:

- a. convert iron ore to metallic iron.
- b. convert copper (I) sulfide to metallic copper.
- c. extract gold from native deposits.
- d. convert pig iron to steel.

41. Sulfide ores are typically processed by roasting; an example of a roasting reaction is:

- a.  $2\text{NiS}(\text{s}) + 3\text{O}_2(\text{g}) \implies 2\text{NiO}(\text{s}) + 2\text{SO}_2(\text{g})$
- b.  $\text{NiS}(\text{s}) + \text{Cl}_2(\text{g}) \implies \text{NiCl}_2(\text{s}) + \text{S}(\text{g})$
- c.  $\text{NiS}(\text{s}) + 2\text{SO}_2(\text{g}) \implies \text{NiSO}_4(\text{s}) + 2\text{S}(\text{g})$
- d.  $\text{NiS}(\text{s}) + \text{CO}(\text{g}) \implies \text{Ni}(\text{l}) + \text{COS}(\text{g})$

42. In the balanced equation for the half reaction in which  $\text{NO}_3^-$  is converted to NO in acid,

- a. 4  $e^-$  are gained and 4 $\text{H}_2\text{O}$  are formed.
- b. 3  $e^-$  are gained and 2 $\text{H}_2\text{O}$  are formed.
- c. 3  $e^-$  are lost and 4 $\text{H}^+$  are formed.
- d. 5  $e^-$  are gained and 2 $\text{H}_2\text{O}$  are formed.

43. In a balanced equation for the half reaction in which  $\text{MnO}_2$  is converted to  $\text{MnO}_4^-$  in base, the products include:

- a. 2 $\text{OH}^-$     b. 3 $e^-$  and 4 $\text{H}_2\text{O}$     c. 4 $\text{OH}^-$     d. 3 $e^-$  and 2 $\text{H}_2\text{O}$ .

44. When the equation for the reaction of  $\text{I}^-$  reacting with  $\text{Cr}_2\text{O}_7^{2-}$  to form  $\text{I}_2$  and  $\text{Cr}^{3+}$  is balanced, the coefficient for the  $\text{I}^-$  is:

- a. 6    b. 4    c. 2    d. 14

45. In the reaction in question 44, the reducing agent is:

- a.  $\text{Cr}_2\text{O}_7^{2-}$     b.  $\text{I}_2$     c.  $\text{H}^+$     d.  $\text{I}^-$