Name: _____   Date: _____

1. If a solute dissolves in an endothermic process:
   A) the entropy of the solution must be greater than its pure components.
   B) Hydrogen bonds must exist between solvent and solute.
   C) strong ion-dipole forces must exist in the solution.
   D) the solute must be a gas.
   E) the entropy of the solution is not important.

2. What is the molarity (M) of a 17.0% by mass solution of sodium acetate, CH_3COONa (molar mass = 82.0 g/mol) in water? The density of the solution is 1.09 g/mL.
   A) 2.26 M
   B) 0.207 M
   C) 2.07 M
   D) 2.45 M
   E) 2.72 M

3. What is the molality of a solution prepared by dissolving 18.5 g of calcium nitrite $[Ca(NO_2)_2]$ in 83.5 g of distilled water?
   A) 1.68 m
   B) 0.0342 m
   C) 0.0855 m
   D) 0.222 m
   E) 0.444 m

4. A solution containing 0.8330 g of a polymer of unknown structure in 170.0 mL of an organic solvent was found to have an osmotic pressure of 5.20 mm of Hg at 25.0°C. Determine the molar mass of the polymer.
   A) 1.75×10^4 g/mol
   B) 2.80×10^4 g/mol
   C) 4.76×10^{-5} g/mol
   D) 3.80×10^4 g/mol
   E) 4.80×10^4 g/mol

5. Calculate the vapor pressure of a solution prepared by dissolving 0.500 mol of a nonvolatile solute in 275 g of hexane (Molar mass= 86.18 g/mol) at 49.6°C. $P°$ hexane = 400.0 torr at 49.6°C.
   A) 346 torr
   B) 154 torr
   C) 245 torr
   D) 54 torr
   E) 400. torr

6. Which one of the following will be a strong electrolyte in an aqueous solution?
   A) $LiNO_3$
   B) $C_6H_{12}O_6$, (glucose)
   C) CCl_4
   D) HF
   E) CH_3CH_2OH, (ethanol)

7. Brass is an alloy of only zinc and copper. Zinc reacts with excess HCl as follows:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2 (g)$$
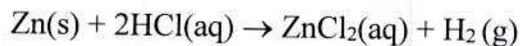
Copper does not react with HCl. When 0.5065 g of a certain brass alloy is reacted with HCl, 0.0985 g of $ZnCl_2$ is produced. What is the percentage by mass of copper in that brass alloy?
   A) 90.7 %
   B) 9.33 %
   C) 75.5 %
   D) 24.5 %
   E) 44.3 %

8. When the following reaction is balanced with the smallest whole coefficients, what will be the coefficient for the ammonia (NH_3)?

$I_2 {}_{(s)} + NH_3 (g) \rightarrow NH_4I {}_{(s)} + N_2 {}_{(g)}$
   A) 8
   B) 18
   C) 7
   D) 17
   E) 1

9. A and B react to form 2 compounds A_2B and AB_2, if A_2B has the composition by mass of 60% A and 40% B. What is the composition of AB_2 by mass?
   A) 27% A, 73% B
   B) 50% A, 50% B
   C) 40% A, 60% B
   D) 76% A, 24% B
   E) 60% A, 40% B

10. Atoms X, Y, Z, and R have the following nuclear compositions:
   $$^{410}_{186}X \qquad ^{410}_{183}Y \qquad ^{412}_{186}Z \qquad ^{412}_{185}R$$

   Which two are isotopes?
   A) X and Z
   B) X and Y
   C) X and R
   D) Z and R
   E) Y and R

11. What is the correct name of $Mn(CO_3)_2$?
   A) manganese (IV) carbonate
   B) manganese carbonate
   C) magnesium (IV) carbonate
   D) manganese (II) carbonate
   E) magnesium (II) carbonate

12. Which of the following is a metalloid?
   A) germanium, Ge, Z = 32
   B) carbon, C, Z = 6
   C) sulfur, S, Z = 16
   D) iridium, Z = 77
   E) bromine, Br, Z = 35

13. The distinguishing characteristic of all nonelectrolyte solutions is that they
   A) do not conduct electricity.
   B) contain ions.
   C) dissociate completely in solution.
   D) always contain acids.
   E) always contain bases.

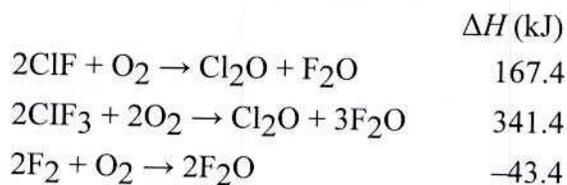14. Which one of the following is the oxidizing agent in the given reaction?
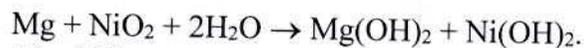
$Mg + NiO_2 + 2H_2O \rightarrow Mg(OH)_2 + Ni(OH)_2.$
A) NiO_2
B) Mg
C) H_2O
D) $Mg(OH)_2$
E) $Ni(OH)_2$

15. Calculate the number of grams of Fe_2O_3 that can react completely with 5.00×10^2 mL of a 0.100 M solution of oxalic acid ($H_2C_2O_4$) according to the following reaction:
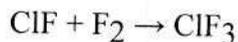
$Fe_2O_3(s) + 6H_2C_2O_4(aq) \rightarrow 2Fe(C_2O_4)_3^{3-} (aq) + 3H_2O (l) + 6H^+(aq)$
A) 1.33 g
B) 47.9 g
C) 7.99 g
D) 3.40 g
E) 4.79 g

16. At 25°C, the following enthalpies of reaction are known:

	ΔH (kJ)
$2ClF + O_2 \rightarrow Cl_2O + F_2O$	167.4
$2ClF_3 + 2O_2 \rightarrow Cl_2O + 3F_2O$	341.4
$2F_2 + O_2 \rightarrow 2F_2O$	–43.4

At the same temperature, calculate ΔH for the reaction:

$ClF + F_2 \rightarrow ClF_3$

A) -108.7 kJ
B) -217.5 kJ
C) +217.5 kJ
D) -130.2 kJ
E) -125.3 kJ

17. For which of the following reaction does $\Delta H^{\circ}_{reaction} = \Delta H^{\circ}_{formation}$
A) $Ag (s) + \frac{1}{2} Br_2 (l) \rightarrow AgBr(s)$
B) $C(diamond) + O_2 (g) \rightarrow CO_2 (g)$
C) $H_2 (g) + CuO (s) \rightarrow H_2O (l) + Cu (s)$
D) $O(g) + O_2 (g) \rightarrow O_3 (g)$
E) $SO_2(g) + H_2 (g) + O_2 (g) \rightarrow H_2SO_4 (l)$

18. What answer should be reported, with the correct number of significant figures, for the following calculation? $(965.43 \times 3.911) + 9413.4136$
   A) 13189
   B) 13189.2
   C) 1.32×10^4
   D) 1.3×10^4
   E) 1.319×10^4

19. _____ are substances with constant composition that can be broken down into elements by chemical processes.
   A) Compounds
   B) Mixtures
   C) Solutions
   D) Alloys
   E) Minerals

20.   A 3.31-g sample of lead nitrate, $Pb(NO_3)_2$, (MM = 331 g/mol), is heated in an evacuated cylinder with a volume of 1.62 L.

The salt completely decomposes when heated, according to the equation

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

What is the total gas pressure in the cylinder after decomposition and cooling to a temperature of 300. K?
   A) 0.380 atm
   B) 0.228atm
   C) 0.0342 atm
   D) 1.28 atm
   E) 5.00 atm

21. Which of the following statement(s) is/are correct?

        I. Root mean square velocity of gas molecules is directly proportional to molar mass.

        II. Real gases do not behave ideally because the molecules occupy significant volume relative to the container volume.

        III. Real gases will behave ideally if their molecules experience intermolecular forces of attraction at low temperatures.

  A) II is correct
  B) I is correct
  C) III is correct
  D) All are correct
  E) II and III are correct

22. A sample of ammonia (NH_3) gas is completely decomposed to nitrogen and hydrogen gases at constant T and V. The total pressure is 867mm Hg at the end of the reaction. The partial pressures of N_2 and H_2 respectively at the end of the reaction are:
  A) 217 mmHg and 650. mmHg
  B) 108 mmHg and 325 mmHg
  C) 183 mmHg and 247 mmHg
  D) 108 mmHg and 434 mmHg
  E) 98.4 mmHg and 560. mmHg

23. Which one of the following statements represent Avogadro's law for gases?
  A) The volume of a sample of gas at constant pressure and temperature is directly proportional to the number of moles.
  B) The volume of a sample of gas at constant pressure is directly proportional to its absolute temperature.
  C) The volume of a sample of gas at constant temperature is inversely proportional to its pressure.
  D) The volume of a sample of gas at constant temperature is directly proportional to its molar mass.
  E) The volume of a sample of gas at constant pressure and temperature is directly proportional to the atmospheric pressure.

24. Nitrogen forms several gaseous oxides , one of them has a density of 1.33 g/L measured at 764 mm Hg and 150 ^{0}C. The formula of this oxide is
  A) NO_2
  B) NO
  C) N_2O_4
  D) N_2O_5
  E) N_2O_2

25. Arrange the following compounds in the order of decreasing boiling points (from left to right) : RbF_2, CO_2, CH_3OH, CH_3Br.
    A) $RbF_2 > CH_3OH > CH_3Br > CO_2$
    B) $CH_3OH > RbF_2 > CO_2 > CH_3Br$
    C) $CH_3Br > CO_2 > RbF_2 > CH_3OH$
    D) $RbF_2 > CO_2 > CH_3Br > CH_3OH$
    E) $CH_3OH > CH_3Br > RbF_2 > CO_2$

26. If the temperature of the water is changed from normal boiling point to 80.0 °C, what is the vapor pressure of water at 80.0 °C? Heat of vaporization of water is 40.15 kJ/mol.
    A) 0.48 atm
    B) 1.00 atm
    C) 0.20 atm
    D) 0.76 atm
    E) 0.54 atm

27. Nickel has a face-centered cubic unit cell with an edge length of 352.4 pm. Calculate the density of nickel.
    A) 8.907 g/cm^3
    B) 2.227 g/cm^3
    C) 4.455 g/cm^3
    D) 38.99 g/cm^3
    E) 11.14 g/cm^3

28. X rays of wavelength 0.154 nm are diffracted from a crystal at an angle of 14.17°. Assuming that n = 1, calculate the distance between layers in the crystal.
    A) 0.315 nm
    B) 0.233 nm
    C) 0.280 nm
    D) 0.212 nm
    E) 0.185 nm

29. The phase diagram of a compound is shown below:
Which statement is **true** regarding this phase diagram?
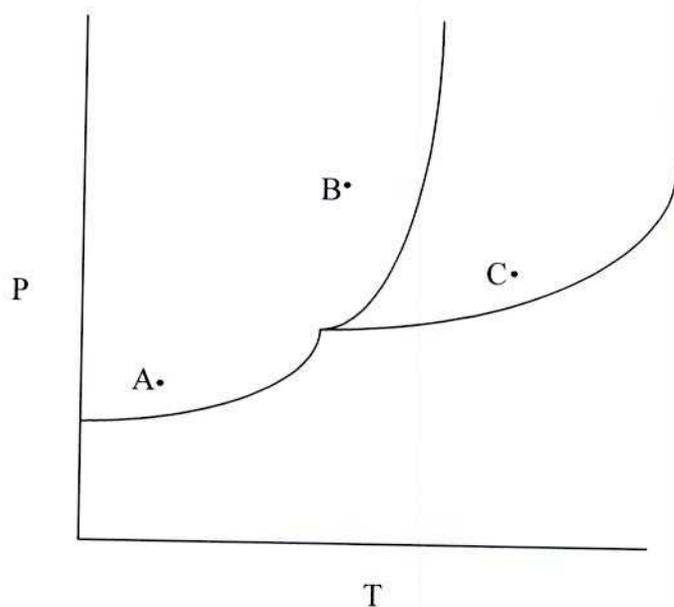
A) If we heat a compound from point A at constant pressure, it will sublime.
B) If we heat a compound from point B at constant pressure, it will boil.
C) If we heat a compound from point C at constant pressure, it will melt.
D) If we heat a compound from point A to B, it will melt.
E) If we decrease the temperature of a compound from point B to A, it will sublime.

30. Which one of the following is the ground-state electron configurations of aluminum (Al)?
A) $1s^2 2s^2 2p^6 3s^2 3p^1$
B) $1s^2 2s^2 2p^5 3s^2 3p^2$
C) $1s^2 2s^2 2p^3 3s^2 3p^4$
D) $1s^2 2s^2 2p^3 3s^2 3p^5$
E) $1s^2 2s^2 2p^1 3s^2 3p^6$

31. The orientation of an atomic orbital in space is associated with
A) the magnetic quantum number (m_l).
B) the spin quantum number (m_s).
C) the angular momentum quantum number (l).
D) the principal quantum number (n).
E) the principal quantum number (n) and the angular momentum quantum number (l) together.

32. The alkali metal elements are found in _____ of the periodic table.
    A) Group 1A
    B) Group 2A
    C) Group 3A
    D) Group 4A
    E) Group 5A

33. Which one of these pairs represents *isoelectronic* species?
    A) K^+ and Cl^-
    B) Mn^{2+} and Ar
    C) Zn^{2+} and Cu^{2+}
    D) Na^+ and K^+
    E) Cl^- and S

34. Which one of these ionic solids would have the largest lattice energy?
    A) $CaCl_2$
    B) $CaBr_2$
    C) NaF
    D) CsI
    E) NaCl

35. How many possible resonance structures will SO_3 molecule have? (Assume all atoms follow the octet rule)
    A) 3
    B) 2
    C) 1
    D) 4
    E) 5

36. The covalent bond with the *greatest* polarity is
    A) B —O
    B) C —O
    C) C —P
    D) S —O
    E) Br —Br

37. Which one of the following formulas represents a covalent compound?
    A) Cl_2O
    B) Na_2O
    C) $CaCl_2$
    D) $CsCl$
    E) Al_2O_3

38. How many sigma and pi bonds are there for the following molecule?
    $$CH_2 = CH - C \equiv N$$

    A) 6 sigma and 3 pi bonds
    B) 4 sigma and 2 pi bonds
    C) 7 sigma and 1 pi bonds
    D) 3 sigma and 3 pi bonds
    E) 5 sigma and 3 pi bonds

39. Considering the nitrosonium ion, NO^+, which one of the following statements about NO^+ is correct according to the molecular orbital theory? (Assume the ordering of molecular orbitals to be like that in O_2)
    A) NO^+ has a bond order of 3 and is diamagnetic.
    B) NO^+ has a bond order of 2 and is paramagnetic.
    C) NO^+ has a bond order of 2 and is diamagnetic.
    D) NO^+ has a bond order of 3 and is paramagnetic.
    E) NO^+ has a bond order of 1 and is paramagnetic.

40. The hybridization of xenone in $XeCl_2$ molecule is (Xenone is the central atom.)
    A) sp^3d
    B) sp^2
    C) sp
    D) sp^3
    E) sp^3d^2

Answer Key

1. A
2. A
3. A
4. A
5. A
6. A
7. A
8. A
9. A
10. A
11. A
12. A
13. A
14. A
15. A
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34. A
35. A
36. A
37. A
38. A
39. A
40. A