Name: _____ Date: _____

1. When two pure substances are mixed to form a solution, then always

   A) there is an increase in entropy.
   B) there is a decrease in entropy.
   C) entropy is conserved.
   D) heat is released.
   E) heat is absorbed.

2. What is the molarity of a solution that is 26.0% by mass phosphoric acid (H_3PO_4) and that has a density of 1.155 g/mL?

   A) 3.06 M
   B) 3.00 M
   C) 2.30 M
   D) 2.30×10^{-3} M
   E) 0.300 M

3. The solubility of nitrogen gas at 25°C and a nitrogen pressure of 522 mmHg is 4.7×10^{-4} mol/L. What is the value of the Henry's Law constant in mol L^{-1} atm^{-1}?

   A) 6.8×10^{-4} mol L^{-1} atm^{-1}
   B) 4.7×10^{-4} mol L^{-1} atm^{-1}
   C) 3.2×10^{-4} mol L^{-1} atm^{-1}
   D) 9.0×10^{-7} mol L^{-1} atm^{-1}
   E) 1.5×10^{3} mol L^{-1} atm^{-1}

4. What is the boiling point of a solution prepared by dissolving 375 g of sulfur (S_8, MW = 256.5g/mol) in 1250 g of CCl_4? (K_b = 5.05°C/*m*, boiling point of pure CCl_4 = 76.7°C)?

   A) 82.6°C
   B) 70.8°C
   C) 75.2°C
   D) 81.2°C
   E) 88.4°C

5. A 0.100 *m* K_2SO_4 aqueous solution has a freezing point of -0.43°C. What is the van't Hoff factor for this solution? K_f = 1.86°C/*m*

A) 2.3
B) 3.0
C) 3.3
D) 1.7
E) 3.2

6. At 40°C, heptane has a vapor pressure of 92.0 torr and octane has a vapor pressure of 31.2 torr. Assuming ideal behavior, what is the vapor pressure of a solution that contains twice as many moles of heptane as octane at 40°C?
A) 71.7 torr
B) 61.6 torr
C) 51.5 torr
D) 76.8 torr
E) 121 torr

7. What types of intermolecular forces exist between hydrogen fluoride molecules?

I. London forces;
II. dipole-dipole interactions;
III. hydrogen bonding;
IV. ion-dipole interactions

A) I, II, and III
B) I, II, and IV
C) II, IIII and IV
D) all of them
E) I and III

8. Arrange the following in order of *increasing* boiling point: Cl_2, HI, Br_2, KI

A) $Cl_2 < Br_2 < HI < KI$
B) $KI < Br_2 < Cl_2 < HI$

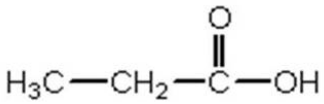
C) $Br_2 < Cl_2 < KI < HI$
D) $HI < Cl_2 < Br_2 < KI$

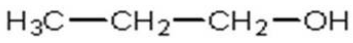
E) $Br_2 < KI < HI < Cl_2$

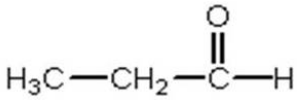
9. The molar enthalpy of vaporization of BBr_3 is 30.5 kJ/mol, and its normal boiling point is 91.0°C. What is the vapor pressure of BBr_3 at 20.0°C ?

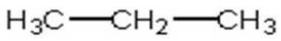
A) 66.1 torr
B) 5.31 torr
C) 53.1 torr
D) 311 torr
E) 113 torr

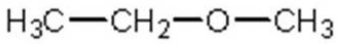
10. Which of the following should have the highest viscosity at a given temperature?

A) 

B) 

C) 

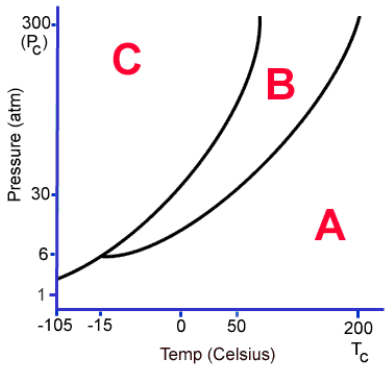
D) 

E) 

11. Platinum (Pt) has a face-centered cubic crystal structure and a density of 21.5 g/cm^3. What is the radius of the platinum atom?

A) 139 pm
B) 196 pm
C) 277 pm
D) 96.0 pm
E) 19.6 pm

12. For the phase diagram shown below, if the substance is held at constant temp. of **-40**°C, the phase change that would occur with a decrease of pressure from 30 atm to 1 atm is:



A) Sublimation.
B) Melting.
C) Vaporization.
D) Deposition.
E) Freezing.

13. A sample of a gas is contained in a 15.0 L cylinder. The temperature is increased from 100 °C to 150 °C. The ratio of final pressure to initial pressure is

A) 1.13
B) 1.00
C) 0.820
D) 0.667
E) 1.50

14. What is the molecular weight of a gas that has a density of 5.75 x 10^{-3} g/cm^3 at STP in g/mol ?

A) **129**
B) **141**
C) 578
D) 3.90
E) 115

15. Hydrogen cyanide (HCN) can be produced according to the following reaction:

$$2CH_4\,(g) + 2NH_3\,(g) + 3O_2\,(g) \rightarrow \quad 2HCN\,(g) + 6H_2O(g)$$

What volume of hydrogen cyanide gas can be obtained from a reaction of 20.0 L CH_4 , 20.0 L NH_3 , and 20.0 L O_2 gases at the same temperature and pressure?

A) 13.3 L
B) 20.0 L
C) 10.0 L
D) 30.0 L
E) 15.0 L

16. A compound composed of carbon, hydrogen, and chlorine effuses through a pinhole 0.411 times as fast as neon (Ne). Select the correct molecular formula for the compound.

A) $CHCl_3$
B) CH_2Cl_2
C) $C_2H_2Cl_2$
D) C_2H_3Cl
E) CCl_4

17. A gaseous mixture containing 19.98 g Ar, 30.00 g NO, and 154.0 g CO_2 has a total pressure of 7.0 atm. What is the partial pressure of CO_2 in the mixture?
A) 3.7×10^3 torr
B) 1.6×10^3 torr
C) 2.7×10^3 torr
D) 1.8 torr
E) 3.2 torr

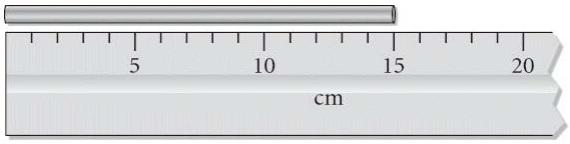
18. A sample of 2.50 moles of NH_3 gas occupies 4.20 L at 47° C. Calculate the pressure of the gas (in atm) using van der Waals equation. (a = 4.17 atm x L^2/mol^2 and b = 0.0371 L/mol)

A) 14.5 atm
B) 65.7 atm
C) 1.48 atm
D) 4.11 atm
E) 6.11 atm

19. A star is estimated to have a mass of 2.0×10^{36} kg. Assuming it to be a sphere of average radius 7.0×10^{5} km, calculate the average density of the star in g/cm^3. ($V = \frac{4}{3}\pi r^3$)

A) 1.4×10^{6}
B) 1.3×10^{33}
C) 1.6×10^{5}
D) 1.3×10^{9}
E) 1.3×10^{8}

20. Read the length of the metal bar with the correct number of significant figures.



A) 15.0 cm
B) 15 cm
C) 15.00 cm
D) 14.9 cm
E) 14.90 cm

21. What is the correct chemical formula for the diiodine pentaoxide?

A) I_2O_5
B) IO_5
C) $2IO_5$
D) I_5O_2
E) $(IO_5)_2$

22. Rutherford bombarded gold foil with alpha (α) particles and found that a small percentage of the particles were deflected. Which of the following was not considered by the model he proposed for the structure of atoms?

A) the total mass of the atom
B) the small size of the nucleus
C) the charge on the nucleus
D) the existence of protons
E) the presence of electrons outside the nucleus

23. What is the coefficient of O_2 when the following combustion reaction is balanced using the smallest set of whole numbers?

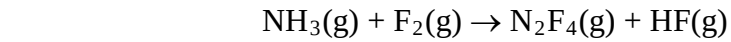
$$\_\_\ C_{18}H_{36}O_2 + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$$

A) 26
B) 9
C) 27
D) 30
E) 15

24. Combustion analysis of 63.8 mg of a compound containing only C, H and O produced 145.0 mg of CO_2 and 59.38 mg of H_2O. What is the empirical formula for the compound?

A) C_3H_6O
B) C_5H_2O
C) CHO
D) C_3H_7O
E) C_6HO_3

25. Ammonia will react with fluorine according to the following **unbalanced** equation:



$$NH_3(g) + F_2(g) \rightarrow N_2F_4(g) + HF(g)$$

How many moles of NH_3 are needed to react completely with 0.517 kg of F_2?

A) 5.44 mol
B) 34.0 mol
C) 27.2 mol
D) 6.80 mol
E) 2.27 mol

26. Choose the statement below that is TRUE.

A) A weak acid solution consists of mostly nonionized acid molecules.
B) The term "strong electrolyte" means that the substance is extremely reactive.
C) A strong acid solution consists mainly of partially ionized acid molecules.
D) The term "weak electrolyte" means that the substance is inert.
E) A molecular compound that does not ionize in solution is considered a strong electrolyte.

27.

Given the reaction

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

determine the total number of electrons involved in this redox reaction in the Mn.

A) 10
B) 8
C) 6
D) 5
E) 2

28.

You have 75.0 mL of a 2.50 M solution of $Na_2CrO_4(aq)$. You also have 125 mL of a 2.50 M solution of $AgNO_3(aq)$. Calculate the CrO_4^{2-} ion concentrations when the two solutions are added together.

A) 0.156 M
B) 0.188 M
C) 0.938 M
D) 2.50 M
E) 0 M

29. A system which undergoes no change in heat (i.e., $q = 0$) and does work on the surroundings has:

A) $w < 0, \Delta U < 0$
B) $w < 0, \Delta U = 0$
C) $w > 0, \Delta U > 0$
D) $w > 0, \Delta U < 0$
E) $w < 0, \Delta U > 0$

30. When 50.0 mL of 0.500 *M* HCl at 25.00°C is added to 50.0 mL of 0.500 *M* NaOH at 25.00°C in a coffee cup calorimeter, the temperature of the mixture rises to 28.20°C. What is the heat of reaction per mole of acid? Assume the mixture has a specific heat capacity of 4.18 J/(g·°C) and that the densities of the reactant solutions are both 1.00 g/mL.

A) 54 kJ
B) 27 kJ
C) 670 J
D) 1300 J
E) 130 kJ

31. Calculate the wavelength associated with a $^{20}Ne^{+}$ ion moving at a velocity of 2.0×10^{5} m/s. The atomic mass of Ne-20 is 19.992 amu (1 amu = 1.66×10^{-24} g).

A) 1.0×10^{-13} m
B) 1.0×10^{-16} m
C) 1.0×10^{-18} m
D) 9.7×10^{12} m
E) 2.0×10^{-13} cm

32. Which one of the following sets of quantum numbers is **NOT** possible?

	n	l	m_l	m_s
I	4	3	-2	+1/2
II	3	0	1	-1/2
III	3	0	0	+1/2
IV	2	1	1	-1/2
V	2	0	0	+1/2

A) II
B) I
C) III
D) IV
E) V

33. If the radius of atom X is greater than the radius of atom Y (assuming X and Y atoms are in the same period), then it is also likely that

A) X has greater metallic characters than Y does.
B) X has a larger electron affinity than Y does.
C) X has a larger effective nuclear charge than Y does.
D) X has a larger first ionization energy than Y does.
E) X is a poorer conductor of electricity than Y when in the solid state.

34. What is the maximum number of electrons having the quantum numbers $n = 3$, $l = 1$ and $m_s = 1/2$?

A) 3
B) 6
C) 9
D) 18
E) 12

35. Use the Born-Haber cycle to calculate the lattice energy of LiCl(s) given the following data:

ΔH(sublimation) Li = 155.2 kJ/mol; IE_1 (Li) = 520 kJ/mol; Bond energy (Cl — Cl) = 242.8 kJ/mol;
EA (Cl) = 348 kJ/mol; ΔH_f (LiCl(s)) = -408.8 kJ/mol.

A) 857 kJ/mol
B) -40 kJ/mol
C) 40 kJ/mol
D) 736 kJ/mol
E) 1553 kJ/mol

36. What is the formal charge on phosphorus in a Lewis structure for the phosphate ion in which all the atoms satisfy the octet rule?

A) +1
B) +2
C) -2
D) -1
E) 0

37. Arrange calcium, rubidium, sulfur, and arsenic in order of decreasing electronegativity.

A) S > As > Ca > Rb
B) S > As > Rb > Ca
C) As > S > Rb > Ca
D) As > S > Ca > Rb
E) Ca > Rb > As > S

38. Use VSEPR theory to predict the electron domain geometry around iodine, the central atom in the ion IF_2^-.

A) trigonal bipyramidal
B) octahedral
C) tetrahedral
D) trigonal planar
E) bent

39. List the following molecules/ions in order of increasing bond order:

C_2^+, F_2^- CN, OF^-

A) $F_2^- < OF^- < C_2^+ < CN$
B) $F_2^- < C_2^+ < CN < OF^-$
C) $CN < C_2^+ < OF^- < F_2^-$
D) $C_2^+ < OF^- < F_2^- < CN$
E) $C_2^+ < CN < OF^- < F_2^-$

40. Which of the following statements about the molecule BN is false?

A) Bond length will increase by adding one electron.
B) Its bond order is two.
C) The total number of electrons is 12.
D) It is diamagnetic
E) Removal of one electron will decrease the dissociation energy.

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
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35. A
36. A
37. A
38. A
39. A
40. A