

All "A" are correct answers:

1. What is the name given to a solution that contains less solute than its dissolving capacity?
  - A) Unsaturated
  - B) Saturated
  - C) Oversaturated
  - D) Supersaturated
  - E) Solvented
  
2. Arrange the following aqueous solutions in order of increasing freezing point:
  - (I) 0.10 m  $\text{Na}_3\text{PO}_4$ ,
  - (II) 0.30 m sugar ( $\text{C}_6\text{H}_{12}\text{O}_6$ ),
  - (III) 0.20 m  $\text{MgCl}_2$
  - A) III < I < II
  - B) I < II < III
  - C) II < I < III
  - D) I < III < II
  - E) II < III < I
  
3. What is the osmotic pressure (atm) of a 0.86 percent by mass solution of NaCl at 25°C? The density of the solution is 1.005 g/mL?
  - A) 7.2
  - B) 5.7
  - C) 3.4
  - D) 2.4
  - E) 8.1
  
4. The solubility of  $\text{CO}_2$  in water at 25°C and 1 atm is 0.034 mol/L. What is its solubility (mol/L) when the partial pressure of  $\text{CO}_2$  in the air is 0.00025 atm?
  - A)  $8.5 \times 10^{-6}$
  - B)  $5.7 \times 10^{-6}$
  - C)  $1.9 \times 10^{-5}$
  - D)  $6.8 \times 10^{-4}$
  - E)  $1.8 \times 10^{-5}$

5. Which one of the following compounds should be soluble in  $\text{CCl}_4$ ?
- A)  $\text{C}_8\text{H}_{18}$
  - B)  $\text{NaOH}$
  - C)  $\text{H}_2\text{O}$
  - D)  $\text{KCl}$
  - E)  $\text{CsBr}$
6. A solution is prepared by dissolving 396 g of sucrose ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) in 624 g of water. What is the vapor pressure of this solution at  $30\text{ }^\circ\text{C}$ ? (The vapor pressure of water is 31.8 mm of Hg at  $30\text{ }^\circ\text{C}$ )  
Molar Mass of sucrose ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) is 342.3 g/mol.
- A) 30.8 mm of Hg
  - B) 0.968 mm of Hg
  - C) 34.6 mm of Hg
  - D) 1.16 mm of Hg
  - E) 62.4 mm of Hg
7. What is the intermolecular force that exists between a calcium ion and water?
- A) Ion-dipole.
  - B) London dispersion forces.
  - C) Covalent bonding.
  - D) Ion-ion.
  - E) Dipole-dipole forces.
8. X rays of wavelength 0.263 nm were used to analyze a crystal. The angle of first-order diffraction ( $n = 1$ ) was  $15.55^\circ$ . What would be the angle for second-order diffraction ( $n = 2$ )?
- A)  $32.42^\circ$
  - B)  $7.78^\circ$
  - C)  $10.81^\circ$
  - D)  $23.33^\circ$
  - E)  $5.18^\circ$

9. How much energy is required to transform 14.0 g ice at 0.0°C to steam at 110.0°C?

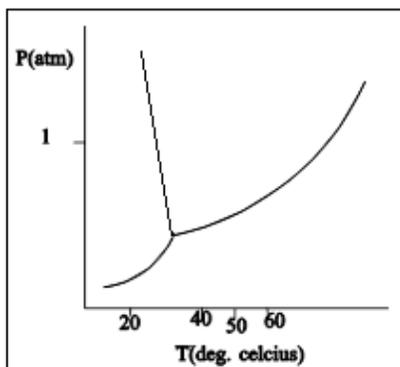
Given the following information:

Specific heat capacities: ice, 2.1 J/g.°C; liquid, 4.2 J/g.°C; steam, 2.0 J/g.°C;

$\Delta H_{\text{fus}} = 6.02 \text{ kJ/mol}$ ,  $\Delta H_{\text{vap}} = 40.7 \text{ kJ/mol}$ .

- A) 42.5 kJ
- B) 660. kJ
- C) 36.6 kJ
- D) 6.16 kJ
- E)  $1.18 \times 10^4 \text{ kJ}$

10. For a substance with the following phase diagram:



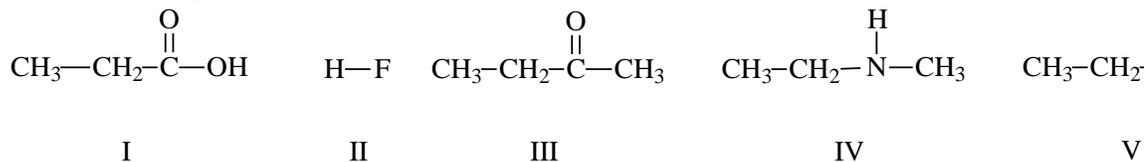
which one of the following statements is correct?

- A) Density of the solid phase is less than that of the liquid phase.
- B) The triple point exists at a pressure higher than 1 atm and temperature greater than 20° C.
- C) The boiling point of the liquid is at 50° C and 1 atm.
- D) The substance will sublime rather than melt as it is heated at 1 atm.
- E) At 1 atm pressure and 40° C, the substance exists as a gas.

11. Platinum, Pt, crystallizes in a face-centered cubic lattice. The atomic radius of a Pt atom is 1.386 Å. Predict the density of platinum. ( $1 \text{ Å} = 1 \times 10^{-8} \text{ cm}$ )

- A) 21.51 g/cm<sup>3</sup>
- B) 10.76 g/cm<sup>3</sup>
- C) 5.378 g/cm<sup>3</sup>
- D) 39.52 g/cm<sup>3</sup>
- E) 29.04 g/cm<sup>3</sup>

12. Which one of the following compounds will not undergo intermolecular hydrogen bonding?



- A) III  
B) I  
C) II  
D) IV  
E) V
13. Under the same experimental conditions, equal volumes of  $\text{CO}_2$  gas and an unknown gas weigh 3.00 and 3.82 grams, respectively. Which of the following is the unknown gas?
- A)  $\text{C}_4\text{H}_8$   
B)  $\text{C}_3\text{H}_4$   
C)  $\text{C}_2\text{H}_4$   
D)  $\text{C}_2\text{H}_6$   
E)  $\text{CH}_4$
14. You have two samples of the same gas in the same size container, with the same pressure. The gas in the first container has a kelvin temperature four times that of the gas in the second container. The ratio of rms (root mean square) speed of the gas in the first container to the gas in the second is
- A) 2 : 1  
B) 1 : 8  
C) 4 : 1  
D) 1 : 4  
E) 1 : 1

15. How many liters of nitrogen, measured at 25 °C and 1.00 atm, will be produced by decomposing 100.0 g of  $\text{NaN}_3$ ?



- A) 56.5 L  
B) 15.9 L  
C) 37.6 L  
D) 1.33 L  
E) 205 L
16. The pressure of ozone ( $\text{O}_3$ ) in the atmosphere is  $1.4 \times 10^{-7}$  atm and the temperature is  $-23^\circ\text{C}$ . How many moles of ozone are in 1.0 L under these conditions?
- A)  $6.8 \times 10^{-9}$   
B)  $2.9 \times 10^{-9}$   
C)  $8.8 \times 10^{-7}$   
D)  $4.1 \times 10^{-9}$   
E)  $3.7 \times 10^{-8}$
17. "The volume of an ideal gas is directly proportional to the number of moles of the gas at constant temperature and pressure" is a statement of \_\_\_\_\_ Law.
- A) Avogadro's  
B) Charles's  
C) Boyle's  
D) Amontons's  
E) Gay-Lussac's
18. At very high pressures ( $\sim 1000$  atm), the measured pressure exerted by real gases is greater than that predicted by the ideal gas equation. This is mainly because
- A) the volume occupied by the gas molecules themselves becomes significant.  
B) real gases will condense to form solids at 1000 atm pressure.  
C) gas phase collisions prevent molecules from colliding with the walls of the container.  
D) real gases will condense to form liquids at 1000 atm pressure.  
E) such high pressures cannot be accurately measured.

19. Use VSEPR theory to predict the molecular geometry for  $\text{SCl}_4$ .
- A) see-saw
  - B) trigonal bipyramidal
  - C) square planar
  - D) tetrahedral
  - E) octahedral
20. What is the hybridization for the C in  $\text{CH}_2\text{CH}_2$  molecule?
- A)  $\text{sp}^2$
  - B)  $\text{sp}^3\text{d}$
  - C)  $\text{sp}^3$
  - D)  $\text{sp}^3\text{d}^2$
  - E) sp
21. According to molecular orbital theory the bond order in the  $\text{C}_2^{2-}$  and  $\text{C}_2$  are respectively:
- A) 3 and 2
  - B) 1.5 and 2.5
  - C) 2 and 3
  - D) 2 for both of them
  - E) 2.5 and 1.5
22. Which one of the following statements is **true** about  $\text{PCl}_5$  molecule?
- A) It has polar bonds, but is a nonpolar molecule.
  - B) It has nonpolar bonds, and is a nonpolar molecule.
  - C) It has nonpolar bonds, but is a polar molecule.
  - D) It has polar bonds, and is a polar molecule.
  - E) It has a  $\text{sp}^3\text{d}^2$  hybridization.
23. How many  $\sigma$  and  $\pi$  bonds are present in the carbonic acid molecule,  $\text{H}_2\text{CO}_3$ ?
- A)  $5\sigma$  and  $1\pi$
  - B)  $2\sigma$  and  $4\pi$
  - C)  $3\sigma$  and  $3\pi$
  - D)  $4\sigma$  and  $2\pi$
  - E)  $6\sigma$  and  $0\pi$

24. Which one of the following is/are a non-polar molecule(s)?

I.  $\text{SO}_2$     II.  $\text{NH}_3$     III.  $\text{BeF}_2$

- A) III only
- B) I only
- C) II only
- D) I and II only
- E) I and III only

25. In the following list, only \_\_\_\_\_ is NOT an example of a chemical reaction.

- A) the condensation of water vapor
- B) dissolution of a metal coin in nitric acid
- C) a burning candle
- D) the rusting (corrosion) of iron
- E) combustion of gasoline in the car

26. What is the correct formula for Iron (III) chloride hexahydrate?

- A)  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$
- B)  $\text{Fe}(\text{Cl} \cdot 6\text{H}_2\text{O})_6$
- C)  $\text{Fe}_3\text{Cl} \cdot 6\text{H}_2\text{O}$
- D)  $\text{FeCl} \cdot (\text{H}_2\text{O})_6$
- E)  $\text{Fe}_2\text{Cl}_3 \cdot (\text{H}_2\text{O})_6$

27. An unknown organic compound contains carbon, hydrogen, and bromine only. The mass percentages of C and H are 12.79% C and 1.61% H. What is the empirical formula of the compound?

- A)  $\text{C}_2\text{H}_3\text{Br}_2$
- B)  $\text{C}_3\text{H}_2\text{Br}_2$
- C)  $\text{C}_2\text{H}_6\text{Br}$
- D)  $\text{C}_5\text{H}_6\text{Br}_2$
- E)  $\text{CH}_3\text{Br}$

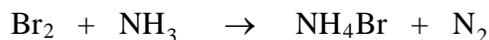
28. A metal has an average atomic mass of 24.31 and consists of 3 isotopes: The abundance of the first isotope is 78.70 % and its mass is 23.985 amu. The second isotope abundance is 11.00 % and its mass is 25.986 amu. What is the atomic mass of the third isotope in amu?

- A) 25.00
- B) 18.97
- C) 23.98
- D) 26.93
- E) 36.70

29. Which one of the following is **incorrectly** named?

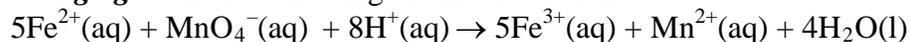
- A)  $\text{HClO}_2$ , hypochlorous acid
- B)  $\text{H}_2\text{SO}_4$ , sulfuric acid
- C)  $\text{HCl}$ , hydrochloric acid
- D)  $\text{HNO}_2$ , nitrous acid
- E)  $\text{H}_2\text{CO}_3$ , carbonic acid

30. Balance the following equation with the **smallest whole number coefficients**. What is the coefficient for  $\text{NH}_3$  in the balanced equation?



- A) 8
- B) 6
- C) 4
- D) 2
- E) 10

31. Identify the **reducing agent** in the following chemical reaction:



- A)  $\text{Fe}^{2+}$
- B)  $\text{MnO}_4^{-}$
- C)  $\text{H}^{+}$
- D)  $\text{Mn}^{2+}$
- E)  $\text{Fe}^{3+}$

32. Which one of the following is considered a **STRONG** electrolyte?
- A)  $\text{NH}_4\text{NO}_3$
  - B) HF
  - C)  $\text{HC}_2\text{H}_3\text{O}_2$
  - D)  $\text{NH}_3$
  - E)  $\text{CH}_3\text{OH}$
33. A 275-g sample of nickel at  $100.0^\circ\text{C}$  is placed in 100.0 mL of water at  $22.0^\circ\text{C}$ . What is the final temperature of the water? Assume that no heat is lost to or gained from the surroundings. Specific heat capacity of nickel =  $0.444 \text{ J}/(\text{g}\cdot^\circ\text{C})$ . The density of water is  $1.00 \text{ g}/\text{mL}$ .
- A)  $39.6^\circ\text{C}$
  - B)  $40.8^\circ\text{C}$
  - C)  $61.0^\circ\text{C}$
  - D)  $79.2^\circ\text{C}$
  - E)  $82.4^\circ\text{C}$
34. When 0.560 g of  $\text{Na}(\text{s})$  reacts with excess  $\text{F}_2(\text{g})$  to form  $\text{NaF}(\text{s})$ , 13.8 kJ of heat is evolved at standard-state conditions. What is the standard enthalpy of formation ( $\Delta H^\circ_f$ ) of  $\text{NaF}(\text{s})$ ?
- A)  $-567 \text{ kJ}/\text{mol}$
  - B)  $24.8 \text{ kJ}/\text{mol}$
  - C)  $-24.8 \text{ kJ}/\text{mol}$
  - D)  $567 \text{ kJ}/\text{mol}$
  - E)  $13.8 \text{ kJ}/\text{mol}$
35. Which one of the following pairs is isoelectronic?
- A)  $\text{La}^{3+}$  and Xe
  - B) Zn and  $\text{Ni}^{2+}$
  - C)  $\text{Ti}^{2+}$  and Ar
  - D) P and As
  - E)  $\text{Cl}^-$  and S

36. What is involved in the formation of chemical bonds?
- A) Valence electrons
  - B) Neutrons
  - C) Protons
  - D) Inner electrons
  - E) Moles
37. Which one of the following statements is NOT correct?
- A) The number of electrons with  $l = 1$  are the same in P and As atoms.
  - B) N and O atoms have the same number of s electrons.
  - C) Cl and Br atoms have the same number of 2p electrons.
  - D) Both F and Al atoms have one unpaired electron.
  - E)  $\text{Li}^+$  and He are isoelectronic
38. If the energy of a photon is  $1.32 \times 10^{-18}$  J, what is its wavelength in nm?
- A) 150. nm
  - B)  $1.99 \times 10^5$  nm
  - C)  $1.99 \times 10^4$  nm
  - D)  $1.87 \times 10^2$  nm
  - E) 142 nm
39. Which of these compounds is most likely to be covalent?
- A)  $\text{NF}_3$
  - B)  $\text{CsOH}$
  - C)  $\text{CaO}$
  - D)  $\text{LiF}$
  - E)  $\text{CaBr}_2$

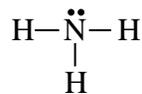
40. Which one of the following Lewis structures is **incorrect**?



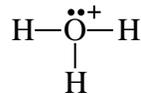
I



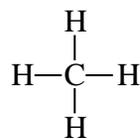
II



III



IV



V

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

## 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
16. A
17. A
18. A
19. A
20. A
21. A
22. A
23. A
24. A
25. A
26. A
27. A
28. A
29. A
30. A
31. A
32. A
33. A
34. A
35. A
36. A
37. A
38. A
39. A
40. A