

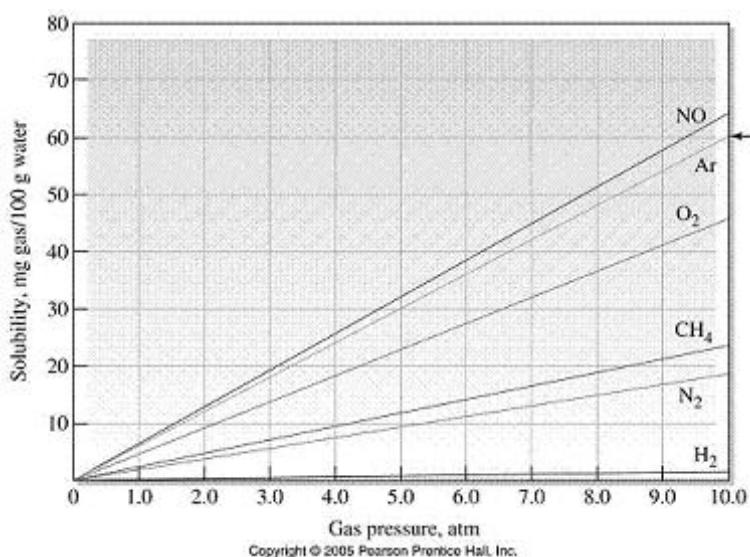
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Which statement is not correct?

- A) The equilibrium vapor pressure above a liquid is independent of the volume of liquid present and the volume of vapor present.
- B) A volatile liquid has a lower boiling point.
- C) The vapor pressure above a liquid increases with temperature.
- D) The boiling point of a liquid is the temperature at which its vapor pressure is equal to the external pressure.
- E) The stronger the intermolecular forces, the lower the boiling point.

Answer: E

2) A 900 g sample of pure water is shaken with air under a pressure of 0.95 atm at 20 °C. How many milligrams of Ar(g) will be present in the water when solubility equilibrium is reached? Use data from Figure and the fact that the mole fraction of Ar in air is 0.00934.



A) 0.12 mg

B) 0.48 mg

C) 0.36 mg

D) 0.24 mg

Answer: B

3) The measured dipole moment of HCl is 1.07 D. If a H - Cl bond is 127 pm and $\mu = \gamma \cdot d$, what is the separated charge in HCl, in coulombs? (1 D = 3.34×10^{-30} C · m)

A) 1.19×10^{-19}

B) 119

C) 3.35×10^{-19}

D) 2.81×10^{-20}

E) 8.43×10^{-3}

Answer: D

4) A solution has a 1:3 mole ratio of cyclopentane to cyclohexane. The vapor pressures of the pure compounds at 25°C are 331 mm Hg for cyclopentane and 113 mm Hg for cyclohexane. What is the mole fraction of cyclopentane in the vapor above the solution?

A) 0.49

B) 0.25

C) 0.66

D) 0.75

E) 0.33

Answer: A

5) What mass of glucose, $C_6H_{12}O_6$, in grams, should be added to 50.0 g H_2O to raise the boiling point to $100.45^\circ C$? ($K_b = 0.512^\circ C m^{-1}$)

- A) 16.0 B) 50 C) 7.9 D) 0.88 E) 160

Answer: C

6) In which atom is the 2p subshell lowest in energy?

- A) Li B) Be C) N D) C E) B

Answer: C

7) Assuming molecular orbital diagrams similar to that of O_2 , use MO theory to predict the proper ordering of bond energies of the following pairs.

- A) $N_2^+ > N_2$ and $O_2 > O_2^+$ B) $N_2 > N_2^+$ and $O_2 > O_2^+$
C) $N_2 > N_2^+$ and $O_2^+ > O_2$ D) $N_2^+ > N_2$ and $O_2^+ > O_2$

Answer: C

8) Which of the following molecules would you expect to have the largest dipole moment (μ)?

- A) COF_2 B) SO_3 C) NO D) NOF_2 E) CS_2

Answer: D

9) Which orbitals overlap in forming the C-C sigma bond of $NC-CH_3$?

- A) sp^2-sp^2 B) sp^3-sp^3 C) $sp-sp$ D) $sp-sp^3$ E) sp^2-sp^3

Answer: D

10) The density of a solution that is 20.0% $HClO_4$ is 1.138 g/mL. Calculate the molarity of the $HClO_4$.

- A) 1.99 B) 2.26 C) 1.75 D) 0.442 E) 3.45

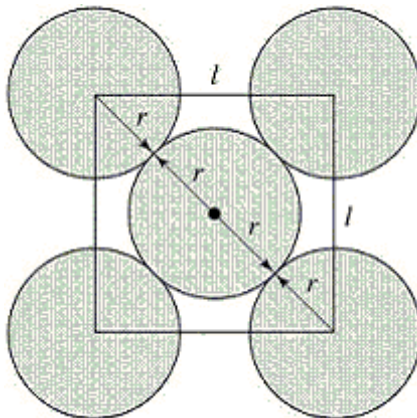
Answer: B

11) What is the osmotic pressure, in atm, produced by a 20.0% glucose ($C_6H_{12}O_6$, FW = 180) solution ($d = 1.08$ g/mL) separated from pure water at $25^\circ C$?

- A) 29.3 B) 4.89 C) 25.1 D) 36.0 E) 27.2

Answer: A

- 12) Copper crystallizes in the cubic close-packed arrangement. The atomic (metallic) radius (labeled r in figure) of a Cu atom is 127.8 pm. Which of the following statement is correct?



- A) The length (labeled l in figure) of the unit cell is 361.5 pm
 B) The volume of that unit cell is $9.3 \times 10^{-23} \text{ cm}^3$
 C) The equivalent numbers of atoms in the unit cell is 5
 D) The density of metallic copper is 9.835 g/cm^3

Answer: A

- 13) How many of the following processes are endothermic?

freezing
 sublimation
 condensation

vaporization
 melting

- A) 1 B) 2 C) 3 D) 4 E) 5

Answer: C

- 14) Which molecular orbital is greatest in energy?

- A) π^* B) σ^* C) π D) p E) σ

Answer: B

- 15) Which of the following molecules contains polar bonds but is nonpolar?

- A) CH_2Cl_2 B) CCl_4 C) H_2O D) NH_3 E) F_2

Answer: B

- 16) The dipole moment of SO_2 is 1.60 D. The shape of SO_2 is

- A) angular.
 B) tetrahedral.
 C) linear.
 D) trigonal planar.
 E) impossible to tell.

Answer: A

17) Which mixture would not be expected to be homogeneous?

- A) ethylene glycol, $\text{HOCH}_2\text{CH}_2\text{OH}$, and H_2O
- B) KBr and H_2O
- C) pentanol, $\text{CH}_3(\text{CH}_2)_3\text{CH}_2\text{OH}$, and hexane, $\text{CH}_3(\text{CH}_2)_4\text{CH}_3$
- D) acetic acid, CH_3COOH , and methanol, CH_3OH
- E) octane, $\text{CH}_3(\text{CH}_2)_6\text{CH}_3$, and heptane, $\text{CH}_3(\text{CH}_2)_5\text{CH}_3$

Answer: C

18) Which of the following would not be angular?

- A) OF_2
- B) ClBr_3
- C) SO_2
- D) H_2O
- E) O_3

Answer: B

19) Which of the following phase transitions indicates sublimation?

- A) solid $\rightarrow$ gas
- B) liquid $\rightarrow$ solid
- C) solid $\rightarrow$ liquid
- D) gas $\rightarrow$ liquid
- E) liquid $\rightarrow$ gas

Answer: A

20) How much heat, in kJ, is required to melt a 1.55 kg block of ice? ($\Delta H_{\text{fus}} = 6.01 \text{ kJ/mol}$)

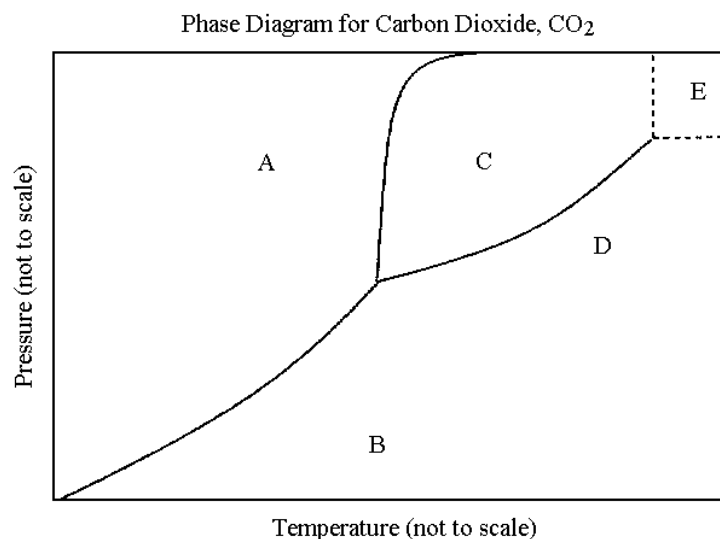
- A) -9.32
- B) 518
- C) -518
- D) 9.32
- E) 4.17

Answer: B

21) Which of the following statements about a colloid is not true?

- A) A colloid is best described as a dispersion of small particles (1-100 nm in size) in a suitable medium.
- B) The particles in a colloid do not settle out with time.
- C) An emulsion is a dispersion of liquid particles in a liquid medium.
- D) A colloidal mixture is heterogeneous in nature.
- E) The Tyndall effect is due to scattering of light by the dissolved particles in the colloid.

Answer: E



22) Consider the phase diagram for CO₂. The point on the graph labelled E represents CO₂ as a

- A) liquid.
- B) supercritical fluid.
- C) solid.
- D) gas.
- E) CO₂ cannot exist at that temperature and pressure.

Answer: B

23) Consider the phase diagram for CO₂. In going from phase A to phase B,

- A) solid CO₂ becomes gaseous.
- B) gaseous CO₂ becomes solid.
- C) liquid CO₂ becomes gaseous.
- D) liquid CO₂ becomes solid.
- E) solid CO₂ becomes liquid.

Answer: A

24) Consider the phase diagram for CO₂. Which process is considered as "condensation"?

- A) A -> C
- B) B -> C
- C) A -> B
- D) C -> A

Answer: B

25) An aqueous solution of a nonelectrolyte boils at 100.32°C. What is its expected freezing point?

($K_b = 0.512^\circ\text{C } m^{-1}$, $K_f = 1.86^\circ\text{C } m^{-1}$)

- A) -1.2
- B) 0
- C) -0.83
- D) -0.32
- E) Additional information is needed.

Answer: A

26) Use the VSEPR method to predict the molecular geometry of XeF_7 .

- A) The VSEPR notation is AX_2E_3 B) The distribution of 22 valence electrons.
C) The Xe and two F atoms lie in a straight line. D) All the describe are correct

Answer: D

27) Which of the following hypothetical steps is predicted to be exothermic?

- A) pure solvent → separated solvent molecules
- B) pure solvent and pure solute → heterogeneous mixture
- C) pure solute → separated solute molecules
- D) separated solvent and solute molecules → solution
- E) not enough information to answer this question

Answer: D

28) Which of the following is most likely to involve sp^3d^2 hybrid orbitals at the central atom?

- A) ClF_4^- B) O_3^- C) H_2O D) N_2O E) CF_4

Answer: A

29) Which would have the lowest boiling point?

- A) OH_2 B) CCl_4 C) NCl_3 D) NH_3 E) BF_3

Answer: E

30) What is the mole fraction of biphenyl, $\text{C}_{12}\text{H}_{10}$, in a solution prepared by dissolving 22.5 g $\text{C}_{12}\text{H}_{10}$ (s) in 285 g of benzene, C_6H_6 (l) ?

- A) 0.0384 B) 0.0732 C) 0.414 D) 0.50 E) 0.0789

Answer: A

31) When two atomic orbitals (AO) are combined to form molecular orbitals (MO), which of the following descriptions of the energy of the resulting molecular orbital is most accurate?

- A) The MOs are of lower energy than the AO.
B) One MO is higher and one MO is lower than the AO.
C) The MOs are of higher energy than the AO.
D) The MOs are the same energy as the AO.
E) none of these

Answer: B

32) When water boils, what primary forces are overcome?

- A) Both of the H-O bonds are broken.
B) An H-O bond is broken.
C) The dipole-dipole intermolecular forces are overcome.
D) Hydrogen bonding forces are overcome.
E) Only the dispersion forces are overcome.

Answer: D

33) At 25°C and constant pressure, carbon monoxide gas combines with oxygen gas to give carbon dioxide gas with the evolution of 10.1 kJ per gram of carbon monoxide consumed. What is the value of ΔH for the balanced reaction?

- A) 141 kJ/mol B) -283 kJ/mol C) -141 kJ/mol D) 283 kJ/mol E) -566 kJ/mol

Answer: E

34) Which statement is incorrect?

- A) For an ideal solution, the ΔH of solution is zero.
- B) When 40.0 mL of ethanol and 60.0 mL of water are mixed, the volume of the mixture is 100.0 mL.
- C) When ethanol and water are mixed, the solution warms slightly. Therefore, the solution process is exothermic.
- D) Ideal solutions form when the intermolecular forces of the solvent and solute are similar.
- E) When an ionic compound dissolves in water, the positive and negative ions separate from each other.

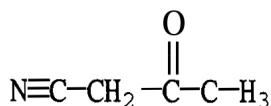
Answer: B

35) It is found that 7.24 kJ of heat is required to vaporize 21.5 g of liquid hexane, C_6H_{14} . Calculate ΔH_{vap} of hexane in kJ/mol.

- A) 0.879
- B) 15.1
- C) 75.6
- D) 0.333
- E) 28.9

Answer: E

36) What is the total number of π bonds in the following structure?



- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Answer: C

37) The boiling points of the noble gases increase going down the group. What type of intermolecular force best accounts for this fact?

- A) hydrogen bonding
- B) ion-dipole
- C) ion-ion
- D) London dispersion
- E) permanent dipole

Answer: D

38) How many electrons are there in the 3d orbitals of ground state calcium atom?

- A) 0
- B) 1
- C) 2
- D) 5
- E) 10

Answer: A

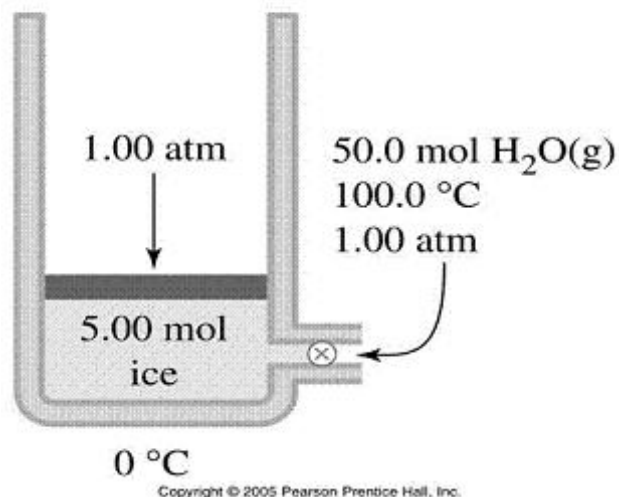
39) Which of the following compounds is predicted to have the highest vapor pressure at STP?

- A) CH_3OH
- B) H_2O
- C) $C_6H_{12}O_6$
- D) CH_4
- E) $C_6H_5NH_2$

Answer: D

- 40) 50.0 mol $\text{H}_2\text{O}(\text{g})$ (steam) at $100.0\text{ }^\circ\text{C}$ and 1.00 atm is added to an insulated cylinder that contains 5.00 mol $\text{H}_2\text{O}(\text{s})$ (ice) at $0\text{ }^\circ\text{C}$. With a minimum of calculation, use the data provided to determine which of the following will describe the final equilibrium condition: Data you will need are $\Delta H_{\text{fusion}} = 6.01\text{ kJ/mol}$, $\Delta H_{\text{vapn}} = 40.6\text{ kJ/mol}$ (at $100\text{ }^\circ\text{C}$), molar heat capacity of $\text{H}_2\text{O}(\text{l}) = 76\text{ J mol}^{-1}\text{ }^\circ\text{C}^{-1}$.

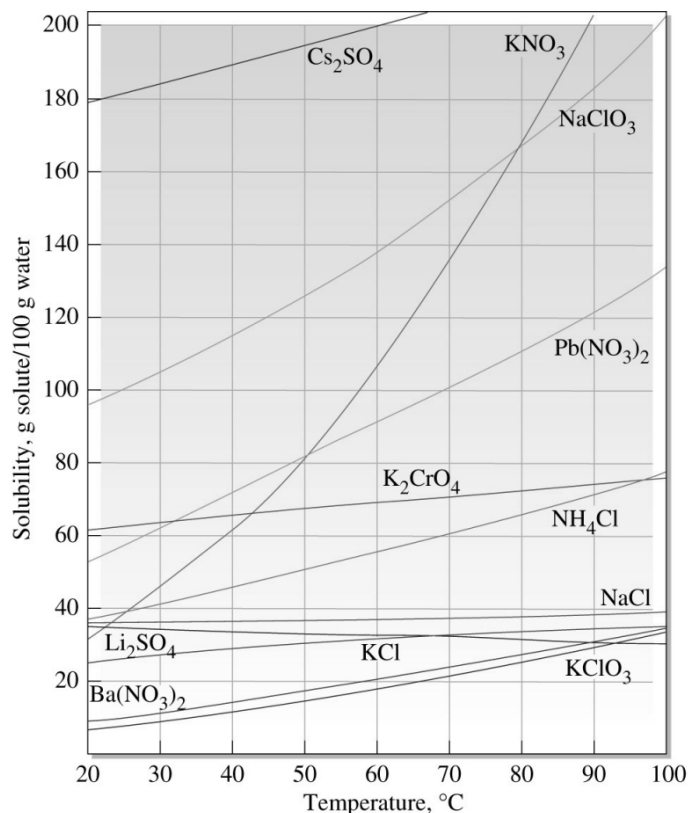
Initial condition



- A) liquid water at $50\text{ }^\circ\text{C}$
C) ice and liquid water at $0\text{ }^\circ\text{C}$

- B) steam at $100\text{ }^\circ\text{C}$
D) steam and liquid water at $100\text{ }^\circ\text{C}$

Answer: D



41) What will happen if 60.0g KNO_3 is added to 100g water at 60°C?

- A) All of the KNO_3 will dissolve.
- B) All of the KNO_3 will dissolve, but then it will precipitate.
- C) Some of the KNO_3 will not dissolve.
- D) The solution will become supersaturated.
- E) None of the KNO_3 will dissolve.

Answer: A

42) Which statement is not true regarding colligative properties?

- A) Since the vapor pressure of the solvent is lowered by a nonvolatile solute, the boiling point of the solution is higher.
- B) Raoult's Law describes the vapor pressure above a solution.
- C) The magnitude depends on whether the solute is an electrolyte or not.
- D) The magnitude depends on the identity of the solute.
- E) The magnitude depends on the concentration.

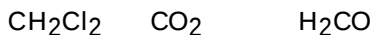
Answer: D

43) Which concentration unit varies with temperature?

- A) mole fraction
- B) molarity
- C) molality
- D) mass percent
- E) All of the above vary with temperature.

Answer: B

44) Which series correctly identifies the hybridization of the central atom in the following species?



- A) sp sp sp³
- B) sp³ sp sp²
- C) sp sp² sp²
- D) sp³ sp² sp
- E) sp² sp³ sp³

Answer: B

45) For which of the following is hydrogen-bonding not an important intermolecular force?

- A) CH₃NH₂ B) N₂ C) HF D) CH₃CH₂OH E) H₂O

Answer: B

46) The hybrid orbitals used by nitrogen in NF₃ are

- A) sp³d². B) sp³. C) sp². D) sp³d. E) sp

Answer: B

47) What mass of NaOH is present in 2.30 L of 5.40 *m* NaOH aolution (*d* = 1.15 g/mL)?

- A) 516 g B) 216 g C) 470 g D) 497 g E) 571 g

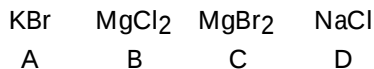
Answer: E

48) According to VSEPR theory, the shape of ICl₄⁻ is described as

- A) tetrahedral.
- B) trigonal bipyramidal.
- C) square planar.
- D) octohedral.
- E) square pyramidal.

Answer: C

49) Arrange the following in the expected order of decreasing melting point (highest melting point first, etc.).



- A) A > B > C > D
- B) C > D > A > B
- C) B > C > D > A
- D) B > C > A > D
- E) C > B > D > A

Answer: C

50) A 135 g sample of carbon disulfide requires 43.2 kJ of heat to vaporize completely. What is the enthalpy of vaporization for carbon disulfide?

- A) 1.77 kJ/mol B) 76.2 kJ/mol C) 24.4 kJ/mol D) 3.13 kJ/mol E) 0.320 kJ/mol

Answer: C