

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

- 1) When a liquid is in equilibrium with its vapor in a closed container: 1) _____
A) the rate at which molecules from the liquid phase enter the gas phase exactly equals the rate at which molecules from the gas phase pass into the liquid phase
B) the amount of gas in the container must exactly equal the amount of liquid
C) the vapor will gradually change back to the liquid state, that is, no vapor will be left
D) a change in temperature will not change the pressure in the container
E) molecules cannot go from the liquid phase to the gas phase because the amount of liquid in the container is constant
- 2) A liquid has a normal boiling point of 78 °C and its vapor pressure is 400 mmHg at 50 °C. To compute the molar heat of vaporization, one needs: 2) _____
A) the mole weight
B) the specific heat
C) the vapor pressure at another temperature
D) nothing, enough information is given
E) none of these
- 3) The relationship between the vapor pressure of a liquid and temperature can be expressed by the Clausius–Clapeyron Equation: 3) _____
$$\ln[P_2/P_1] = [\Delta H_{\text{vap}}/R] \times [1/T_1 - 1/T_2]$$

Ethanol (C₂H₅OH) has a normal boiling point of 78.3 °C and $\Delta H_{\text{vap}} = 39.3$ kJ/mol. What is the vapor pressure of ethanol at 50.0 °C? Note that 1 atm = 760 torr.
A) 234 torr B) 670 torr C) 118 torr D) 354 torr E) 485 torr
- 4) A substance has a heat of fusion of 61.5 kJ/mol and a heat of deposition of -167.4 kJ/mol. What is the heat of sublimation in kJ/mol? 4) _____
A) -61.5 B) -105.9 C) 228.9 D) 167.4 E) 105.9
- 5) Arrange the following compounds in order of increasing boiling point: I 1-propanol, (structure CH₃CH₂CH₂OH); II 1,2-propanediol, (CH₃CH(OH)CH₂OH); III 1,2,3-propanetriol, (glycerol, with structure HOCH₂CH(OH)CH₂OH) 5) _____
A) III, I, II B) II, III, I C) I, III, II D) I, II, III E) III, II, I
- 6) In a particular unit cell, all sides are equal in length and all angles are right angles. There is an atom at each corner and one at the center of each side. Which statement is true? 6) _____
A) This is a body-centered cubic cell containing 4 atoms
B) This is an fcc with 2 atoms per unit cell
C) This is a simple cubic cell
D) This has 4 atoms per unit cell
E) none of these

7) A solution prepared by dissolving 4.00 g KCl in 36.0 g H₂O is said to be: 7) _____
 A) 0.100% KCl by mass
 B) 0.111% KCl by mass
 C) 11.1% KCl by mass
 D) 9.00% KCl by mass
 E) 10.0% KCl by mass

8) A 1.00 molal solution of NaCl in water contains: 8) _____
 A) 1.00 mol NaCl per 1000.0 mL solution
 B) 1.00 mol NaCl per 1000.0 g H₂O
 C) 1.00 mol NaCl per 1000.0 kg H₂O
 D) 1.00 g NaCl per 1000.0 g H₂O
 E) 1000.0 g NaCl per 1000.0 g H₂O

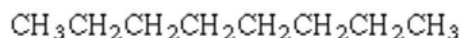
9) Which of the following organic substances is most soluble in water? 9) _____



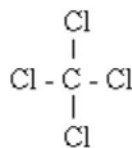
benzene



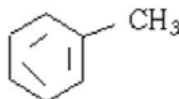
pyridine



octane



carbon tetrachloride



toluene

- A) toluene
 B) benzene
 C) octane
 D) pyridine
 E) carbon tetrachloride

10) A handbook gives the aqueous solubility of carbon monoxide at 0 °C and 1 atm CO pressure to be 0.0354 mg CO per mL of solution. What would be the molarity of CO in water if the partial pressure of CO is 0.00036 atm. 10) _____
 A) 4.5×10^{-7} M
 B) 3.2×10^{-3} M
 C) 1.3×10^{-3} M
 D) 2.9×10^{-4} M
 E) 1.3×10^{-5} M

11) The vapor pressures of pure propyl alcohol and isopropyl alcohol are 21.0 mmHg and 45.2 mmHg, respectively, at 25 °C. What is the composition of the vapor in equilibrium with a propyl alcohol - isopropyl alcohol solution at 25 °C in which the mole fraction of propyl alcohol, x_{prop} , is 0.250? 11) _____
 A) $x_{\text{iso}} = 0.317$, $x_{\text{prop}} = 0.683$
 B) $x_{\text{iso}} = 0.750$, $x_{\text{prop}} = 0.250$
 C) $x_{\text{iso}} = 0.512$, $x_{\text{prop}} = 0.488$
 D) $x_{\text{iso}} = 0.866$, $x_{\text{prop}} = 0.134$

- 12) Solutions are made that contain 0.10 moles of each of the following compounds in 100 g of H₂O. 12) _____
 Choose the compound whose solution will have the highest freezing point.
 A) Ca₃(PO₄)₂
 B) Mg(CH₃CO₂)₂
 C) NaI
 D) K₂SO₄
 E) Sr(NO₃)₂

- 13) Exactly 375.0 mg of an unknown protein is dissolved in enough water to give 50.00 mL of solution and the osmotic pressure determined as 3.25 mmHg at 298 K. Estimate the molar mass of this protein. Note that 1.00 atm = 760. mmHg. 13) _____
 A) 56,400 g/mol B) 3,600 g/mol C) 42,900 g/mol D) 139,000 g/mol

- 14) For the reaction: C₂H₄Br₂ + 3 KI → C₂H₄ + 2 KBr + KI₃, When the rate of reaction is 2.0 × 10⁻⁵ M/s, what is the value of d[KI]/dt in M/s? 14) _____
 A) -6.0 × 10⁻⁵
 B) -4.0 × 10⁻⁵
 C) -0.67 × 10⁻⁵
 D) -2.0 × 10⁻⁵
 E) -1.0 × 10⁻⁵

- 15) The reaction A + B → C + D is second order in A and zero order in B. The value of k is 0.012 M⁻¹ min⁻¹. What is the rate of this reaction when [A] = 0.125 M and [B] = 0.435 M? 15) _____
 A) 1.3 M min⁻¹
 B) 1.9 × 10⁻⁴ M min⁻¹
 C) 3.4 × 10⁻³ M min⁻¹
 D) 5 × 10⁻⁴ M min⁻¹
 E) 1.5 × 10⁻³ M min⁻¹

- 16) Data for the reaction A + B → C are given below. Find the rate constant for this system. 16) _____

Experiment	[A], M	[B], M	Initial rate, M/s
1	0.030	0.060	2.5 × 10 ⁻⁵
2	0.030	0.020	2.5 × 10 ⁻⁵
3	0.060	0.060	10.0 × 10 ⁻⁵

- A) 2.8 × 10⁻² Ms⁻¹
 B) 1.7 × 10⁻³ Ms⁻¹
 C) 1.7 × 10⁻³ M⁻¹s⁻¹
 D) 2.8 × 10⁻² M²s⁻¹
 E) 2.8 × 10⁻² M⁻¹s⁻¹

- 17) What is the rate law for the following reaction and its mechanism? 17) _____
- $$2\text{HgCl}_2 + \text{C}_2\text{O}_4^{2-} \rightarrow 2\text{Cl}^- + 2\text{CO}_2 + \text{Hg}_2\text{Cl}_2 \quad (\text{overall reaction})$$
- proposed mechanism:
- $$\text{HgCl}_2 + \text{C}_2\text{O}_4^{2-} \rightleftharpoons \text{HgCl}_2\text{C}_2\text{O}_4^{2-} \quad (\text{F})$$
- $$\text{HgCl}_2\text{C}_2\text{O}_4^{2-} + \text{C}_2\text{O}_4^{2-} \rightarrow \text{Hg} + 2\text{C}_2\text{O}_4\text{Cl}_2 \quad (\text{S})$$
- $$\text{Hg} + \text{HgCl}_2 \rightarrow \text{Hg}_2\text{Cl}_2 \quad (\text{F})$$
- $$2\text{C}_2\text{O}_4\text{Cl}_2 \rightarrow \text{C}_2\text{O}_4^{2-} + 2\text{Cl}^- + 2\text{CO}_2 \quad (\text{F})$$
- A)** Rate = $k[\text{HgCl}_2][\text{C}_2\text{O}_4^{2-}]^2$
 B) Rate = $k[\text{HgCl}_2][\text{C}_2\text{O}_4^{2-}]$
 C) Rate = $k[\text{HgCl}_2]^2[\text{C}_2\text{O}_4^{2-}]$
 D) Rate = $k[\text{Hg}_2\text{Cl}_2]$
 E) Rate = $k[\text{HgCl}_2]^2[\text{C}_2\text{O}_4^{2-}]^2$
- 18) A catalyst: 18) _____
- I) lowers activation energy
 - II) provides an alternate reaction pathway
 - III) is consumed in the reaction and therefore does not appear in the chemical equation of each mechanism
 - IV) speeds up a reaction
 - V) is heterogeneous if it is in a different phase than the reactants
- A) I, III, and IV
 B) I, IV, and V
 C) II, III, and IV
 D) II and IV
E) I, II, IV, and V
- 19) The first order reaction $\text{A} \rightarrow \text{products}$ has $t_{1/2} = 150$ sec. What percent of the initial amount of A remains *unreacted* after 300 sec? 19) _____
- A) 100% B) 50% C) 12.5% D) 0.0% **E) 25%**
- 20) For the reaction: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$, $K_c = 92.0$ 20) _____
 When equilibrium concentrations of HI and I_2 are $[\text{HI}] = 0.115$ M and $[\text{I}_2] = 0.250$ M, the equilibrium concentration of $[\text{H}_2]$ is:
- A) 9.56 M
 B) 1.74×10^3 M
 C) 0.135 M
D) 5.75×10^{-4} M
 E) 5.00×10^{-3} M
- 21) For which of the following reactions does $K_p = K_c$? 21) _____
- A) $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g})$ B) $\text{H}_2(\text{g}) + \text{I}_2(\text{s}) \rightleftharpoons 2\text{HI}(\text{g})$
 C) $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ **D) $3\text{Fe}(\text{s}) + 4\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{Fe}_3\text{O}_4(\text{s}) + 4\text{H}_2(\text{g})$**

- 22) For the reaction $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ $K_c = 0.0454$ at 261°C . If a vessel is filled with these gases such that the initial concentrations are $[\text{PCl}_5] = 0.25\text{M}$, $[\text{PCl}_3] = 0.20\text{M}$, and $[\text{Cl}_2] = 2.25\text{M}$, in which direction will a reaction occur and why? 22) _____
- A) toward products because $Q = 2.8$
 - B) it is at equilibrium
 - C) toward reactants because $Q = 1.8$**
 - D) toward reactants because $Q = 0.0454$
 - E) toward products because $Q = 0.56$
- 23) Consider the reaction: 23) _____
- $$\text{CH}_4(\text{g}) + 4 \text{Cl}_2(\text{g}) \rightleftharpoons \text{CCl}_4(\text{l}) + 4 \text{HCl}(\text{g}) \quad \Delta H^\circ -398 \text{ kJ/mol}$$
- The equilibrium is displaced to the right if:
- A) some hydrogen chloride is added
 - B) the pressure is lowered
 - C) some carbon tetrachloride is removed**
 - D) the temperature is raised
 - E) none of these
- 24) Colligative properties are similar in that they all: 24) _____
- A) depend on the number of solute particles in solution**
 - B) have no effect on the properties of solution
 - C) are due to solvent - solvent interactions
 - D) depend on solvent-solute interactions
 - E) none of these
- 25) If increasing the concentration of A in a chemical reaction causes no increase in the rate of the reaction, then we may say: 25) _____
- A) the reaction rate is first order in [A]
 - B) the reaction rate is zero order in A
 - C) the reaction rate is zero order in [A]**
 - D) A is a catalyst
 - E) A is not involved in the reaction