

Name: \_\_\_\_\_ Key \_\_\_\_\_

This test is closed note/book, but one 8.5 x 11 handwritten crib sheet (one sided) is permitted.

Please turn off cell phones.

Calculators are permitted; however, computers, PDAs, and other electronic devices with a keyboard are not permitted. Cell phones may not be used as calculators.

Complete the Scantron card as shown below. **Identify your version as indicated to receive credit.**

A total of 50 minutes will be allotted for the exam. Answer every question. There is no guessing penalty.

**Circle Your Section**

Mindi Ogden	A1 W 3-6
Denise Enekwa	A2 W 3-6
Deborah Ortiz	A3 W 3-6
Yo-Yuan Cheng	A4 W 3-6
Wei Long	A4 W 3-6
Chiaolong Hsiao	B1 Th 3-6
Michael Rood	B2 Th 3-6

1. What is  $[H^+]$  in an aqueous solution with a pH of 9.097?
- A)  $2 \times 10^{-8} M$
  - B)  $1 \times 10^{-1} M$
  - C)  $9.1 M$
  - D)  $4.9 M$
  - E)  $8.0 \times 10^{-10} M$

answer E

$$[H^+] = 10^{-9.097} = 8.0 \times 10^{-10}$$

2. What is pOH of an aqueous solution with  $[HCl] = 10^{-9} M$
- A) 9
  - B)  $10^{-5}$
  - C) 5
  - D) -5
  - E) 7

answer E. In pure water,  $[H^+] = [OH^-] = 10^{-7}$ . If you add any acid or base to a concentration of much less than  $10^{-7}$ , it will not alter the pH or the pOH. If you answered C (pOH=5), that would imply that adding a slight amount of strong acid to water would render the water basic (pH>7, pOH<7). Not possible.

3. What concentration of HF ( $K_a = 7.2 \times 10^{-4}$ ) has the same pH as that of 0.044 M HCl?
- A) 0.37 M
  - B) 2.7 M
  - C) 0.044 M
  - D)  $3.2 \times 10^{-6} M$
  - E)  $1.6 \times 10^{-2} M$

answer B

This requires an ICE diagram

4. What is the molality of a solution of 39.6 g of ethanol ( $CH_3CH_2OH$ ) in 442 mL of water?
- A) 1.94 m
  - B) 89.6 m
  - C) 0.0350 m
  - D) 1.78 m
  - E) 0.0338 m

answer A

5. A 90.0 g sample of glucose (a non-dissociating, non-volatile solute with the formula  $C_6H_{12}O_6$ ) is dissolved in 180.0 g water. What is the vapor pressure of this solution at  $100^\circ C$ ?
- A) 722 torr
  - B) 760 torr
  - C) 29 torr
  - D) 23 torr
  - E) 738 torr

answer A

$$(90 \text{ g}) [6(12)+12+6(16) \text{ g/mol}]^{-1} = n_{\text{glucose}} = 90/180 = 0.5$$

$$(180 \text{ g}) [18 \text{ g/mol}]^{-1} = n_{\text{water}} = 10.0$$

$$X_{H_2O} = n_{H_2O} / (n_{H_2O} + n_{\text{glucose}}) = 10 / (10.0 + 0.5) = 10 / 10.5 = 0.95$$

$$0.95 * 760 = 722 \text{ torr}$$

6. For the reaction:  $aA(g) + bB(g) \rightleftharpoons cC(g) + \text{heat}$   
with  $a = 1$ ,  $b=1$  and  $c=3$ . An increase in total pressure (at const T)
- A) increases the number of moles of A
  - B) decreases the number of moles of A
  - C) does not change the number of moles of A

answer A

There are more molecules in the gas phase on the RH side, to increasing the P drives it to the left

7. For the reaction:  $aA(g) + bB(g) \rightleftharpoons cC(g) + \text{heat}$   
with  $a = 1$ ,  $b=1$  and  $c=3$ . An increase in total pressure (at const T)
- A) increases the equilibrium constant
  - B) decreases the equilibrium constant
  - C) does not change the equilibrium constant

answer C

Changing P will not change K

8. For the reaction:  $aA(g) + bB(g) \rightleftharpoons cC(g) + \text{heat}$   
with  $a = 1$ ,  $b=1$  and  $c=3$ . An increase in T
- A) Increases the number of moles of A.
  - B) Decreases the number of moles of A
  - C) Does not change the number of moles of A

answer A

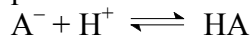
For a reaction that evolves heat, adding heat drives it to the left (and changes K).

9. Which one of the following is the strongest intermolecular force in Ar(liq)?
- A) dipole-dipole interactions
  - B) ionic bonding
  - C) London dispersion forces
  - D) polar covalent bonds
  - E) hydrogen bonding

answer C

Argon is non-polar.

10. The equilibrium constant for the reaction

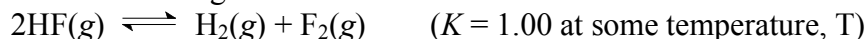


is:

- A)  $\frac{K_w}{K_b}$
- B)  $\frac{1}{K_a}$
- C)  $K_a$
- D)  $K_w K_a$
- E)  $K_b$

answer B

11. Consider the following reaction:



Given 1.0 mol of HF(g), 0.5 mol of H<sub>2</sub>(g), and 1.0 mol of F<sub>2</sub>(g) are mixed in a 1.00-L flask, determine the direction required to achieve equilibrium.

- A) the system is at equilibrium.
- B) the system shifts to the right to reach equilibrium.
- C) the system shifts to the left to reach equilibrium.
- D) the direction of the driving force cannot be determined by the information provided.

answer B

12. Air is 79% N<sub>2</sub> and 21% O<sub>2</sub> weight to volume. Calculate the density of air at 1.0 atm, 25°C.

- A) 14.1 g/L
- B) 2.46 g/L
- C) 0.590 g/L
- D) 1.18 g/L
- E) 1.29 g/L

answer D

% is weight to volume

for 1 g of air

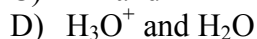
$$\text{N}_2: (0.79\text{g}) (28\text{g/mol})^{-1} = n_{\text{N}_2} = 0.0282 \text{ mol}$$

$$\text{O}_2: (0.21\text{g}) (32\text{g/mol})^{-1} = n_{\text{O}_2} = 0.0066 \text{ mol}$$

$$V_{\text{TOT}} = (n_{\text{N}_2} + n_{\text{O}_2})RT/P = (0.0348 \text{ mol}) (0.082 \text{ L atm mol}^{-1} \text{ K}^{-1})(298 \text{ K})(1 \text{ atm})^{-1} \\ = 0.850 \text{ L}$$

$$1\text{g}/0.850 \text{ L} = 1.18 \text{ g/L}$$

13. Which of the following does not represent a conjugate acid-base pair?



answer B

14. A cylinder is fitted with a movable piston containing an ideal gas. The pressure inside the cylinder is  $P_i$  and the volume is  $V_i$ . What is the new pressure in the system when the piston decreases the volume of the cylinder by half, at constant T?

A)  $2V_iP_i$

B)  $(1/4)P_i$

C)  $P_i^2$

D)  $2P_i$

E)  $(1/2)P_i$

answer D

15. Consider two samples of helium in the gas phase in separate containers of the same volume and pressure. Sample 1 has an absolute temperature four times that of Sample 2. Calculate the molar ratio  $n_1/n_2$ .

A) 1:2

B) 4:1

C) 1:1

D) 1:4

E) 2:1

answer D

16. What is the equilibrium expression for the reaction  
 $2\text{SO}_2(aq) + \text{O}_2(aq) \rightleftharpoons 2\text{SO}_3(aq)$  ?

- A)  $\frac{[\text{SO}_3]}{[\text{SO}_2][\text{O}_2]}$   
 B)  $\frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$   
 C)  $\frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]^2}$   
 D)  $\frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2}$

answer B

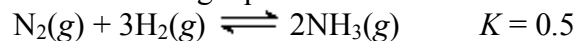
17. Which of the following has the highest boiling point?

- A)  $\text{N}_2$   
 B)  $\text{CH}_4$   
 C)  $\text{F}_2$   
 D)  $\text{NH}_3$   
 E) Ne

answer D

18A.

Consider the following equilibrium:



Each reactant and product is placed in a 1.00-L container (i.e., all three in the same container) to a partial pressure of 2 atm. Which way will the reaction initially proceed?

- A) To the left.  
 B) To the right.  
 C) The system is at equilibrium.  
 D) We need to know the temperature.

answer B (\*\*revised)

$Q = 2^2 / 2 \times 2^3 = 0.25$ . Since  $Q < K$  the reaction will go to the right to reach equilibrium.

19A. A system in a state of chemical equilibrium is

- A) microscopically dynamic and macroscopically dynamic.  
 B) microscopically static and macroscopically dynamic.  
 C) microscopically dynamic and macroscopically static.  
 D) microscopically static and macroscopically static.

answer C

18B. To calculate the freezing point of an ideal dilute solution of a single, non-dissociating solute, the minimum information one must know is

- I. the molality (of the solute).
  - II. the freezing-point-depression constant of the solvent
  - III. the freezing point of the pure solvent.
  - IV. the molecular weight of the solute.
  - V. the weight of the solvent.
- A) II, III, IV
  - B) I only
  - C) II only
  - D) II, III, V
  - E) I, II, III only

answer E

19B. Which of the following statements is true?

- A) Catalysts change equilibrium constants.
- B) If all opposing processes proceed at identical rates, a system is at equilibrium.
- C) An exothermic reaction consumes heat.
- D) The concentration of the products equals that of the reactants at equilibrium.

answer B

20. This is exam version (look at the top of the page):

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

answer A

Constants:

$$1 \text{ mole} = 6.022 \times 10^{23} \text{ atoms}$$

$$1 \text{ mole} = 6.022 \times 10^{23} \text{ molecules}$$

$$1 \text{ mole} = 6.022 \times 10^{23} \text{ ions}$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$1 \text{ J (Joule)} = 1 \text{ kg} \frac{\text{m}^2}{\text{s}^2}$$

$$c = 3.0 \times 10^8 \text{ m/s}$$

$$\text{Mass of an Electron} = 9.10939 \times 10^{-31} \text{ kg}$$

$$\text{Mass of a Proton} = 1.67 \times 10^{-27} \text{ kg}$$

$$\text{Mass of a Neutron} = 1.67 \times 10^{-27} \text{ kg}$$

$$R = 0.0821 \frac{\text{Latm}}{\text{molK}}$$

$$R = 8.31 \frac{\text{J}}{\text{molK}}$$

$$V.P.(H_2O, 373K) = 760 \text{ torr}$$

Solubility Rules

1. All alkali metal salts are soluble.
2. All ammonium ( $\text{NH}_4^+$ ) salts are soluble.
3. All chlorides, bromides, and iodides are soluble except those of  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$ , and  $\text{Pb}^{2+}$ .
4. All nitrates, chlorates, and perchlorates are soluble.
5. All sulfates except those of  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$ , and  $\text{Ag}^+$ .
6. All carbonates, chromates, oxalates, and phosphates are insoluble except those of the alkali metals and ammonium.
7. All hydroxides are insoluble except those of the alkali metals.

Bonding

$$\text{Formal Charge} = V - (L + 0.5 S)$$

V = Number of Valence Electrons

L = The Number of Lone Pair Electrons

S = The Number of Shared Electrons

Stoichiometry:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{Molarity} = M = \frac{\text{mole of solute}}{\text{L of solvent}}$$

$$n \text{ (number of moles)} = \frac{\text{mass}}{\text{Molar Mass}}$$

$$M_1 V_1 = M_2 V_2$$

Quantum Mechanics

$$c = \lambda \nu$$

$$E = mc^2$$

$$\lambda = \frac{h}{p}$$

$$\hat{H}\psi = E\psi$$

$$\Delta x * m \Delta v \geq \frac{h}{4\pi}$$

$$\text{Maximum Occupancy} = 2n^2$$



Solutions

$$P = X_1 \cdot P^\circ$$

$$m = \text{molality} = \frac{\text{mol of solute}}{\text{kg of solvent}}$$

$$\Delta T_f = -m \cdot K_f$$

$$\Delta T_b = m \cdot K_b$$

$$X_1 = \text{mole fraction} = \frac{n_1}{n_{\text{total}}}$$

$$\Pi = MRT$$


---

Gas Laws

$$P_1 V_1 = P_2 V_2$$

$$V_1 T_2 = V_2 T_1$$

$$PV = nRT$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\text{Kelvin} = ^\circ\text{C} + 273.15$$

$$\left(P + a \frac{n^2}{V^2}\right)(V - nb) = nRT$$

$$P_{\text{total}} = P_1 + P_2 + \dots + P_n$$

$$KE(\text{mol}) = \frac{3}{2} RT \text{ (monoatomic)}$$

$$KE(\text{particle}) = \frac{1}{2} mu^2$$


---

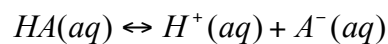
Acid-Base Chemistry

$$pH = -\log[H^+]$$

$$pOH = -\log[OH^-]$$

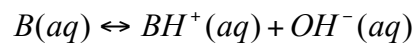
$$K_w = K_a K_b$$

$$pH + pOH = 14$$



$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_w = 1 \times 10^{-14} \text{ at } 25^\circ\text{C}$$



$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

$$pKa = -\log K_a$$

$$pKw = 14 \text{ at } 25^\circ\text{C}$$