

USE PEN ONLY

_____ (PRINT)
LAST NAME, FIRST NAME

SECTION

_____ (RIN)

1. - 18 _____ (72pts)

4. _____ (28pts)

_____ (Total)

SHOW ALL WORK!

All essay questions must be answered with complete sentences. All calculations must be clearly shown the individual steps and with units and their cancellations in at least one step of the problem. Answers must be written with the proper number of significant figures. Only exams written in ink are eligible for a re-grade. Academic Integrity is expected of everyone and anyone caught cheating will receive an F in the course.

1-18. _____

Print Initials _____

(4pts for each question, all or nothing, fill in your answers for questions 1-18 with a Number 2 pencil on the Scantron Answer Sheet)

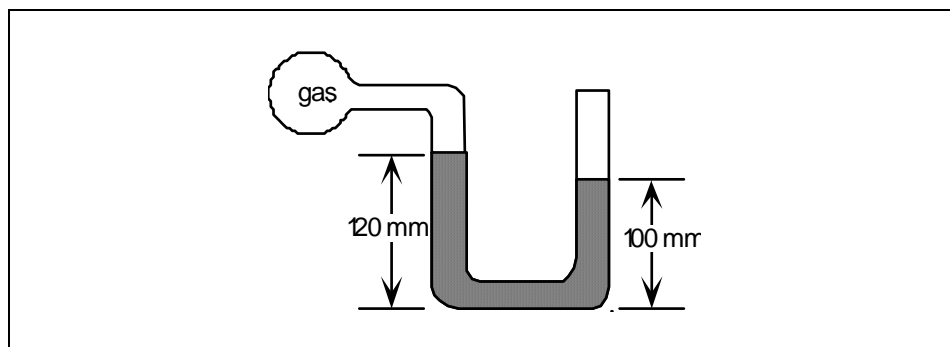
1. A solution containing 70.0% HF by mass has a density of 1.25 g/mL. Its molarity, with respect to HF (Molar Mass: 20.0 g/mol) is

- (A) 43.8 M (B) 35.5 M (C) 28.0 M (D) 84.3 M

2. A 20.0-mL sample of 0.30 M HBr is titrated with 0.15 M NaOH. What is the pH of the solution after 40.3 mL of NaOH have been added to the acid?

- (A) 2.95 (B) 3.13 (C) 13.14 (D) 11.05 (E) 10.87

3. The height of the mercury in the right arm open to atmospheric pressure (760 mmHg) is 100 mm and the height in the left arm is 120 mm.



What is the pressure of the gas in the bulb?

- (A) 20 mmHg (C) 640 mmHg
(B) 740 mmHg (D) 780 mmHg

4. The partial pressures of a gaseous mixture are given below. What is the mole fraction of hydrogen?

$P(\text{H}_2) = 200 \text{ mmHg}$, $P(\text{CO}_2) = 150 \text{ mmHg}$, $P(\text{CH}_4) = 320 \text{ mmHg}$, $P(\text{C}_2\text{H}_4) = 105 \text{ mmHg}$

- (A) 0.417 mmHg (B) 0.388 mmHg (C) 0.258 mmHg (D) 0.200 mmHg

5. At 25 °C, a gas diffuses twice as fast as SO₂. The gas could be

Molar Masses	
He	4. g·mol ⁻¹
CH ₄	16. g·mol ⁻¹
O ₂	32. g·mol ⁻¹
SO ₂	64. g·mol ⁻¹
HI	128. g·mol ⁻¹

(A) He (B) CH₄ (C) O₂ (D) HI

6. A system that does no work but which transfers heat to the surroundings has

(A) $q < 0, \Delta E > 0$ (B) $q < 0, \Delta E = 0$ (C) $q > 0, \Delta E > 0$
 (D) $q > 0, \Delta E < 0$ (E) $q < 0, \Delta E < 0$

7. A 10.0 g sample of silver is heated to 100.0 °C and then added to 20.0 g of water at 23.0 °C in an insulated calorimeter. At thermal equilibrium the temperature of the system was measured as 25.0 °C. What is the specific heat of silver?

Data for Water
specific heat _(water) 4.2 J·g ⁻¹ ·°C ⁻¹

(A) 17 J/g·K (C) 0.11 J/g·K
 (B) 0.22 J/g·K (D) 34 J/g·K

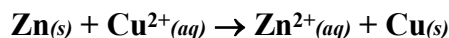
8. What is the energy in J of a photon with a wavelength of 615 nm?

(A) $3.230 \times 10^{-19} \text{ J}$ (B) $3.230 \times 10^{-28} \text{ J}$ (C) $1.222 \times 10^{-31} \text{ J}$ (D) $4.075 \times 10^{-40} \text{ J}$

9. Given the data at 1 atm and 25.0 °C:

Species	ΔH_f^0 (kJ·mol ⁻¹)
$\text{Cu}^{2+}_{(aq)}$	+64.4
$\text{Zn}^{2+}_{(aq)}$	-152.4

calculate the standard heat of reaction, ΔH_{25}^0 , for the reaction



- (A) 216.8 kJ are evolved per mole.
- (B) 88.0 kJ are evolved per mole.
- (C) 88.0 kJ are absorbed per mole.
- (D) 216.8 kJ are absorbed per mole.

10. For potassium metal, the work function, Φ , is 3.68×10^{-19} J. What is the longest wavelength which could just generate a photoelectron?

- (A) 500 nm (B) 450 nm (C) 400 nm (D) 350 nm (E) 550 nm

11. A 1.00 g sample of NH_4NO_3 is decomposed in a bomb calorimeter. The heat capacity of the system is $1.23 \text{ kJ}\cdot\text{K}^{-1}$. The temperature increases by 6.12 K. What is the molar heat of decomposition for ammonium nitrate?

Molar Mass
NH_4NO_3 80.0 g·mol ⁻¹

- (A) -602 kJ·mol⁻¹ (C) 7.53 kJ·mol⁻¹
- (B) -398 kJ·mol⁻¹ (D) 164 kJ·mol⁻¹

12. The kinetic-molecular theory of ideal gases assumes that

- (A) the collisions of gas molecules are inelastic.
- (B) all gas molecules travel at the same speed.
- (C) gas molecules exert no pressure on the walls.
- (D) the volume of a gas molecule is negligible.

13. The existence of discrete (quantized) energy levels in an atom may be inferred from

- (A) experiments on the photoelectric effect.
- (B) diffraction of electrons by crystals.
- (C) X-ray diffraction by crystals.
- (D) atomic line spectra.

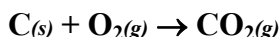
14. The ionization energy of the electron in the 1s (most stable) orbital of the hydrogen atom is -13.6 eV. The energy of the electron after promotion to the 2s orbital is

- (A) 0 (B) -3.4 eV (C) -13.6 eV (D) -14.6 eV (E) -27.2 eV

15. More heat is derived from cooling one gram of steam at 100 °C to water at 50 °C than from cooling one gram of liquid water at 100 °C to 50 °C because

- (A) water is a poor thermal conductor.
- (B) the steam is hotter than the water.
- (C) the steam occupies a greater volume than the water.
- (D) the density of water is greater than that of steam.
- (E) the heat of condensation is evolved.

16. The heat of combustion for one mole of carbon is 410 kJ.



The reaction is exothermic to the right. How many kJ of heat would be liberated on the complete combustion of 60 g of carbon?

Atomic Molar Mass	
C	$12.0 \text{ g}\cdot\text{mol}^{-1}$

- (A) 5×410 kJ
- (B) 12×410 kJ
- (C) 44×410 kJ
- (D) 60×410 kJ

17. The energy of a photon is greatest in the case of

- (A) X-radiation. (C) visible light.
(B) ultraviolet radiation. (D) infrared radiation.

18. A liter of carbon dioxide gas is compared to a liter of hydrogen gas, both gases at 25 °C and 2 atm. Which statement is correct?

- (A) The CO₂ and H₂ molecules have the same average speed.
(B) There are more molecules of H₂ than CO₂ present.
(C) The CO₂ and H₂ molecules hit the walls of the containers with the same frequency.
(D) The CO₂ molecules are on the average moving slower than the H₂ molecules.
(E) The average kinetic energy of the CO₂ molecules is greater than that of the H₂ molecules.

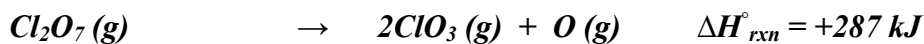
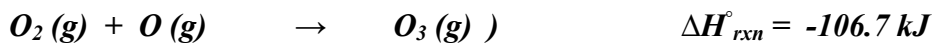
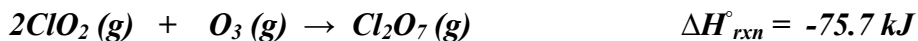
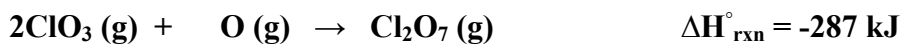
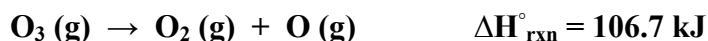
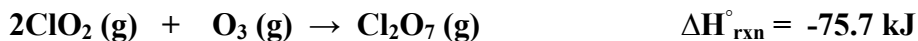
4. _____ (28pts)

_____ **Print Initials**

A (10pts) Use Hess's Law and the information below to determine the $\Delta H^\circ_{\text{rxn}}$ for



Given Information:



B. (10 pts) A hydrogen atom undergoes a transition from an initial state which has quantum number $n = 3$ to a final state with quantum number $n = 5$. Is this an absorption or emission?

ABSORPTION **EMISSION** (circle one)

What is the wavelength of the photon involved in this transition?

$$\Delta E = E_f - E_i = E_5 - E_3 = -(2.18 \times 10^{-18} \text{ J}) [1/9 - 1/25] = 1.53 \times 10^{-19} \text{ J}$$

$$\lambda = (h c) / \Delta E = 13 \times 10^{-7} \text{ m} = 1300 \text{ nm}$$

C. (8 pts) A mixture consists of 75.0 g of He and 75.0 g of Ne at 298K in a 500 L container. What are the partial pressures of each gas and what is the total pressure in the container?

$$n_{\text{He}} = 75.0\text{g}/4.003 \text{ g/mol} = 18.74 \text{ mole He}$$

$$n_{\text{Ne}} = 75.0\text{g}/20.18 \text{ g/mol} = 3.72 \text{ mole Ne} \quad n_T = 22.46 \text{ moles gas}$$

$$P_T = (22.46 \text{ moles})(0.082 \text{ L atm/mole K})(298\text{K})/ 500\text{L} = 1.1 \text{ atm}$$

$$P_{\text{He}} = (18.74/22.46) 1.1 \text{ atm} = 0.92 \text{ atm} \quad P_{\text{Ne}} = (3.72/22.46) 1.1 \text{ atm} = 0.18 \text{ atm}$$

Equations and Constants

$$N_A = 6.022 \times 10^{23} \quad R = 8.314 \text{ J/mol K} = 0.08206 \text{ L atm/mol K}$$

$$m_e = 9.10939 \times 10^{-31} \text{ kg} \quad c = 2.998 \times 10^8 \text{ m/sec} \quad h = 6.626 \times 10^{-34} \text{ J s}$$

$$R_{\text{Rydberg}} = 1.096776 \times 10^7 \text{ m}^{-1}$$

$$1 \text{ atm} = 760 \text{ mmHg} = 760 \text{ torr} = 1.01325 \text{ bar} = 1.01325 \times 10^5 \text{ Pa}$$

$$PV = nRT \quad P_A = \chi_A P_{\text{Total}} \quad u_{\text{rms}} = \sqrt{\frac{3RT}{MM}} \quad \chi_A = n_A / n_{\text{total}}$$

$$q = mc\Delta T \quad \Delta E = q + w \quad dw = -pdV \quad \Delta H = \Delta E + P\Delta V$$

$$\Delta H_{\text{rxn}}^{\circ} = \sum m \Delta H_{\text{f}}^{\circ}(\text{products}) - \sum n \Delta H_{\text{f}}^{\circ}(\text{reactants})$$

$$E = h\nu \quad c = \nu\lambda$$

$$\lambda = \frac{h}{mu} \quad p = \frac{h}{\lambda} \quad E_n = -(2.18 \times 10^{-18} \text{ J}) 1/n^2 \text{ (Hydrogen Atom)}$$

$$\text{KE}(\text{electron}) = h\nu - \Phi \quad \text{KE} = \frac{1}{2}mu^2$$

$$\frac{1}{\lambda} = R_{\text{Rydberg}} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \text{ (where } n_2 > n_1)$$

$$\text{pH} = -\log[\text{H}^+] \quad \text{pOH} = -\log[\text{OH}^-] \quad \text{pH} + \text{pOH} = 14 \quad K_a \cdot K_b = K_w$$

$$K_w = 1.0 \times 10^{-14} \text{ (at } 25^\circ\text{C)} \quad M_1V_1 = M_2V_2$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$