

USE PEN ONLY

ANSWER KEY (PRINT)

LAST NAME, FIRST NAME

SECTION

1. _____ (25pts)

2. _____ (25pts)

3. _____ (25pts)

4. _____ (25pts)

_____ (Total)

SHOW ALL WORK!

All essay questions must be answered with complete sentences. All calculations must be clearly shown with units and their cancellations in at least one step of the problem. Answers must have 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. _____ (25pts)

_____ **Print Initials**

(5pts for each question, all or nothing, place the letter answer on the line provided before the question)

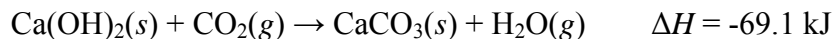
___ **C** ___ (i) Given the following mixture of gases: 2.00 g He, 28.0 g N₂ and 16.0 g O₂, what is the total pressure at 24.0 °C if the gases are confined in a 2.00 L container? (Molar Masses: He 4.00 g/mol, N₂ 28.0 g/mol, O₂ 32.0 g/mol)

- (A) 1.97 atm (B) 60.9 atm (C) 24.4 atm (D) 8.12 atm (E) 45.3 atm

___ **E** ___ (ii) Which of the following is a correct set of quantum numbers for an electron in a 3d orbital?

- (A) $n = 3, l = 0, m_l = -1, m_s = \frac{1}{2}$
(B) $n = 3, l = 1, m_l = 3, m_s = -\frac{1}{2}$
(C) $n = 3, l = 2, m_l = 3, m_s = \frac{1}{2}$
(D) $n = 3, l = 3, m_l = 2, m_s = -\frac{1}{2}$
(E) $n = 3, l = 2, m_l = -2, m_s = \frac{1}{2}$

___ **D** ___ (iii) Calcium hydroxide, which reacts with carbon dioxide to form calcium carbonate, was used by the ancient Romans as mortar in stone structures. The reaction for this process is



What is the enthalpy change if 3.8 mol of calcium carbonate is formed?

- (A) -18 kJ (B) -69 kJ (C) -73 kJ (D) -2.6×10^2 kJ (E) -3.5×10^2 kJ

___ **C** ___ (iv) Which of the following gases will be the slowest to diffuse through a room?

- (A) CH₄ (B) H₂S (C) CO₂ (D) H₂O (E) Ne

___ **D** ___ (v) What is the wavelength of a photon whose energy is 4.56×10^{-19} J?

- (A) 2.06×10^{23} m
(B) 9.06×10^{-44} m
(C) 6.88×10^{14} m
(D) 4.36×10^{-7} m
(E) 6.57×10^{26} m

2. _____ (25pts)

Print Initials

(5pts for each question, all or nothing, place the letter answer on the line provided before the question)

 E (i) How does the volume of one mole of an ideal gas change when the pressure is changed from 2 atm to 4atm and the temperature is changed from 150K to 300K?

- (A) The volume increases by a factor of 2.
- (B) The volume decreases by a factor of 2.
- (C) The volume increases by a factor of 4.
- (D) The volume decreases by a factor of 4.
- (E) The volume does not change.

 C (ii) A system that does no work but which receives heat from the surroundings has

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

 D (iii) Benzene is a starting material in the synthesis of nylon fibers. Its specific heat capacity is 1.74 J/(g·K). If 16.7 kJ of energy is absorbed by a 225g sample of benzene at 20.0°C, what is its final temperature?

- (A) -22.7°C (B) 36.7°C (C) 42.7°C (D) 62.7°C (E) 20.0°C

 D (iv) What is the energy difference between the $n = 3$ and $n = 5$ states of the Hydrogen atom?

- (A) 8.72×10^{-20} J
- (B) 1.36×10^{-19} J
- (C) 2.42×10^{-19} J
- (D) 1.55×10^{-19} J
- (E) 1.09×10^{-18} J

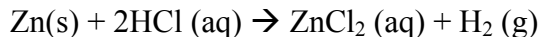
 A (v) According to the kinetic–molecular theory of gases,

- (A) gaseous molecules are in constant random motion and collisions are perfectly elastic.
- (B) the absolute temperature of a gas depends on its molar mass.
- (C) the pressure exerted on a gas affects the speed of its molecules.
- (D) gaseous molecules can travel in straight or curved paths.
- (E) all gaseous molecules are diatomic.

3. _____ (25pts)

_____ **Print Initials**

(15 points) A sample of zinc metal is allowed to react completely with an excess of hydrochloric acid.



The hydrogen gas produced is collected over water at 27.0°C. If 6.40 L of the gas were collected at a barometric pressure of 745 mmHg, what is the amount of zinc metal (in grams) that was consumed in the reaction?

(Water vapor pressure at 27.0°C is 26.7 mmHg)

1. Find the pressure of H₂ gas collected:

$$P_{\text{H}_2} = P_{\text{atm}} - P_{\text{H}_2\text{O}} = 745 \text{ mmHg} - 26.7 \text{ mmHg} = 718.3 \text{ mmHg}$$

$$718.3 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.945 \text{ atm}$$

2. Use the ideal gas law to find the moles of H₂ gas collected

$$PV = nRT \quad (0.945 \text{ atm})(6.40\text{L}) = n(0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{K})(300\text{K})$$

$$n = 0.246 \text{ moles of H}_2 \text{ gas produced}$$

3. Look at balanced equation for stoichiometric relationship between H₂ and Zn (s).

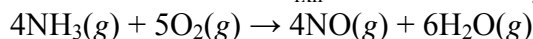
One mole of Zn is consumed for every one mole of H₂ produced so:

$$0.246 \text{ mol H}_2 \times \frac{1 \text{ mol Zn}}{1 \text{ mol H}_2} = 0.246 \text{ mol Zn consumed in reaction}$$

4. Convert moles Zn consumed into grams Zn consumed

$$0.246 \text{ mol Zn} \times \frac{65.39 \text{ g}}{1 \text{ mol Zn}} = 16.1 \text{ g of Zn consumed}$$

(10 points) What is the value of $\Delta H^\circ_{\text{rxn}}$ for the following reaction?



[Given: $\Delta H^\circ_f(\text{NH}_3(\text{g})) = -45.9 \text{ kJ/mol}$; $\Delta H^\circ_f(\text{NO}(\text{g})) = 90.3 \text{ kJ/mol}$;
 $\Delta H^\circ_f(\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ/mol}$]

$$\Delta H^\circ_{\text{rxn}} = \sum m \Delta H^\circ_f(\text{products}) - \sum n \Delta H^\circ_f(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(4(90.3 \text{ kJ/mol})) + (6(-241.8 \text{ kJ/mol}))] - [(5(0)) + (4(-45.9 \text{ kJ/mol}))] = -906 \text{ kJ}$$

4. _____ (25pts)

Print Initials

(13 points) When light of wavelength 358.1 nm falls on the surface of potassium metal, the speed (u) of the dislodged electron is 6.40×10^5 m/s.

(a) What is the kinetic energy (in Joules) of the dislodged electron?

(b) What is the value of the work function (Φ , in Joules) of potassium?

$$\text{(a) } KE = \frac{1}{2} mu^2 = \frac{1}{2} (9.11 \times 10^{-31} \text{ kg})(6.40 \times 10^5 \text{ m/s})^2 = 1.87 \times 10^{-19} \text{ kgm}^2/\text{s}^2$$

(1 J = 1 kgm²/s²) so KE = 1.87 x 10⁻¹⁹ J

$$\text{(b) } KE(\text{electron}) = h\nu - \Phi$$

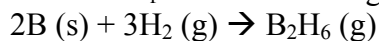
$$\text{Energy of photon} = h\nu = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s})(2.998 \times 10^8 \text{ m/s})}{358.1 \times 10^{-9} \text{ m}} = 5.55 \times 10^{-19} \text{ J}$$

$$1.87 \times 10^{-19} \text{ J} = 5.55 \times 10^{-19} \text{ J} - \Phi$$

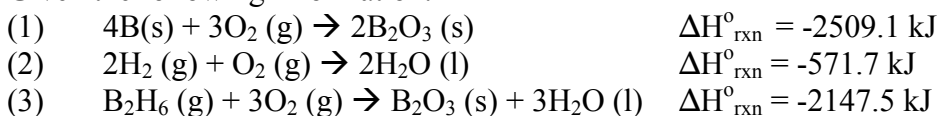
$$\Phi = 3.68 \times 10^{-19} \text{ J}$$

The Hess's Law Problem is on the next page ...

(12 points) Calculate ΔH_f° for the following reaction:

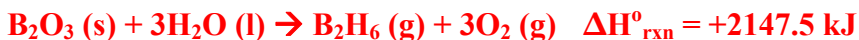


Given the following information:

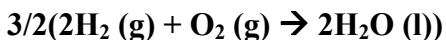


The steps above are numbered for clarity (also note that the order in which you manipulate the steps doesn't matter, as long as you end up with your target reaction in the end):

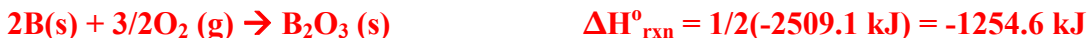
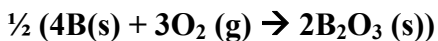
First, reverse step (3) and therefore change the sign of $\Delta H_{\text{rxn}}^\circ$:



Next, multiply step (2) by $3/2$ and therefore multiply the $\Delta H_{\text{rxn}}^\circ$ by $3/2$:



Next, multiply step (1) by $1/2$ and therefore multiply the $\Delta H_{\text{rxn}}^\circ$ by $1/2$:



Now add the steps together (shown in red) to get your overall target reaction and add each step's $\Delta H_{\text{rxn}}^\circ$ to find the target reaction's $\Delta H_{\text{rxn}}^\circ$:

