MULTIPLE CHOICE (2 pts each): Write the letter corresponding to the correct answer on the line next to each question (ONLY ONE ANSWER FOR EACH). To receive full credit, the LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION.

B 1.) Which law tells you that no more than two electrons can occupy an orbital?

(a)Hund's Rule (b)Pauli Exclusion Principle (c)Aufbau Principle (d)Hess's Law (e)Boyle's Law

D 2.) How many moles are present in 68.2 L of a gas at STP?

(a) 1.95 mol (b) 2.67 mol (c) 2.83 mol (d) 3.04 mol (e) 3.19 mol

$68.2\,L\left(\frac{1\,mol}{22.4\,L}\right) = 3.0446\,mol$

A 3.) A sample of hydrogen gas is collected over a beaker of water. If the measured pressure is 3.452 atm, what is the pressure of the hydrogen gas? (vapor pressure of water = 0.026 atm)

(a) 3.426 atm (b) 3.478 atm (c) 3.955 atm (d) 4.426 atm (e) 4.955 atm

$3.452\,atm - 0.026\,atm = 3.426\,atm$

C 4.) How many liters of ammonia can be obtained from 5.00 L of hydrogen and excess nitrogen? ($3\,H_2 + N_2 \rightarrow 2\,NH_3$)

(a) 1.33 L (b) 2.67 L (c) 3.33 L (d) 4.67 L (e) 5.33 L

$5.00\,L\,H_2\left(\frac{2\,L\,NH_3}{3\,L\,H_2}\right) = 3.333\,L$

D 5.) Baking soda and vinegar are mixed together in a beaker. The reaction that results is occurring in a(an)

(a) buffered system (b) closed system (c) isolated system (d) open system (e) vascular system

B 6.) After two chemicals were mixed in a beaker, the beaker felt very cold. What type of reaction has occurred?

(a) endomeric (b) endothermic (c) exomeric (d) exothermic (e) isothermic

D 7.) What is the rms velocity of a single atom of nitrogen at 278 K?

(a) 586.3 m/s (b) 604.3 m/s (c) 658.5 m/s (d) 703.8 m/s (e) 732.4 m/s

$v_{rms} = \sqrt{\frac{3(8.314\,J/mol\,K)(278\,K)}{0.014006\,kg/mol}}$ $N = 14.0067\,g/mol$

B 8.) In a reaction involving gases, negative work would result when

(a) $\Delta V = 0$ (b) $\Delta V > 0$ (c) $\Delta V < 0$

$W = -P\Delta V$

A 9.) The height of a wave is its

(a) amplitude (b) frequency (c) photon (d) quantum (e) wavelength

B 10.) What color of light corresponds to a frequency of 5.17×10^{14} Hz?

(a) red (b) yellow (c) green (d) blue (e) violet

$c = \lambda \nu$

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated boxes or tables when they are provided.

1. What is the partial pressure of CO_2 in a mixture containing 0.559 mol H_2O, 0.258 mol CO_2, and 0.112 mol NO_2. The total pressure of the mixture of gases is 1.36 atm.

$P_{CO_2} = (X_{CO_2})(P_T)$

$X_{CO_2} = \frac{0.258 \text{ mol } CO_2}{(0.559 \text{ mol} + 0.258 \text{ mol} + 0.112 \text{ mol})} = 0.2777$

$P_{CO_2} = 0.2777(1.36 \text{ atm}) = 0.377696 \text{ atm}$

Answer:

0.378 atm

2. A 0.525 mol sample of ethanol is burned in a calorimeter, raising the temperature of 100.0 g of water from 22.0 °C to 25.5 °C.

(a) What is the heat released during this experiment?

$q_{H_2O} = ms\Delta T = (100.0 g)(4.184 J/g°C)(25.5°C - 22.0°C)$

$= 1464.4 \text{ J released}$

Answer:

1460 J

(b) What would be the ΔH value per mole of ethanol burned?

$q_{H_2O} = -q_{etoH}$ 0.525 mol used in rxn

$\Delta H = \frac{-1464.4 \text{ J}}{0.525 \text{ mol}} = -2789.33 \text{ J/mol}$

Answer:

−2790 J/mol

3. A sample of sodium hydroxide was neutralized by sulfuric acid according to the following equation:

$$H_2SO_4 + 2\,NaOH \rightarrow 2\,H_2O + Na_2SO_4$$

The standard enthalpy of formation for the compounds involved are:

H_2SO_4: ΔH_f° = -753.13 kJ/mol × 1 mol

H_2O: ΔH_f° = - 285.83 kJ/mol × 2 mol

NaOH: ΔH_f° = - 425.93 kJ/mol × 2 mol

Na_2SO_4: ΔH_f° = -1387.56 kJ/mol × 1 mol

a.) What is the enthalpy of the neutralization reaction?

$\Delta H_{rxn} = \Delta H_{prod} - \Delta H_{reactants}$

$\Delta H_{prod} = (-1387.56\ kJ + \overbrace{-285.83\ kJ \times 2}^{-571.66}) = -1959.22\ kJ$

$\Delta H_{react} = (-753.13\ kJ + \overbrace{-425.93\ kJ \times 2}^{-851.86}) = -1604.99\ kJ$

$\Delta H_{rxn} = -1959.22\ kJ - (-1604.99\ kJ) = -354.23\ kJ$

Answer: **-354.23 kJ**

b.) How much heat would be released if 3.125 mol NaOH was neutralized with excess acid?

-354.23 kJ is for 2 mol NaOH

$$3.125\ mol\ NaOH \left(\frac{-354.23\ kJ}{2\ mol\ NaOH}\right) =$$

$$= -553.484\ kJ$$

Answer: **-553.5 kJ**

4. Given the following information:

2 × : $Fe\,(s) + Cl_2\,(g) \rightarrow FeCl_2\,(s)$ ΔH = -342 kJ × 2

flip sign: $2\,FeCl_3\,(s) \rightarrow Cl_2\,(s) + 2\,FeCl_2$ ΔH = + 114 kJ

What is the ΔH_{rxn} for the equation: $2\,Fe\,(s) + 3\,Cl_2 \rightarrow 2\,FeCl_3$

$2Fe(s) + 2Cl_2 \longrightarrow 2FeCl_2$ $\Delta H = -684\ kJ$

$2FeCl_2 + Cl_2 \longrightarrow 2FeCl_3$ $\Delta H = -114\ kJ$

$2Fe(s) + 3Cl_2 \longrightarrow 2FeCl_3$ $\Delta H = -798\ kJ$

Answer: **-798 kJ**

5. 238.4 J of energy is needed to expand a gas from 2.500 L to 5.000 L.

(a) Calculate the work done against a pressure of 0.500 atm.

$w = -P\Delta V$

$= -(0.500 atm)(5.000 L - 2.500 L)$

$= -1.25\ L \cdot atm \left(\frac{101.32 J}{1 L \cdot atm}\right) = 126.65 J$

Answer: $-127 J$

(b) Calculate the heat required for this system.

$\Delta u = q + w$

$238.4 J = q + (-126.65 J)$

$q = 365.05 J$

Answer: $365.1 J$

6. Write electron configurations for the following elements using the notation indicated:

(a) Carbon (C) (orbital notation – with arrows) 6e⁻

$\frac{\uparrow\downarrow}{1s}\ \frac{\uparrow\downarrow}{2s}\ \frac{\uparrow}{2p}\ \frac{\uparrow}{2p}\ \frac{}{2p}$

(b) Iron (Fe) (spdf notation – with superscripts) 26e⁻

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

(c) Zirconium (Zr) (noble gas configuration) 40-36=4

$[Kr]\ 5s^2 4d^2$

or

$[Kr]\ \frac{\uparrow\downarrow}{5s}\ \frac{\uparrow}{4d}\ \frac{\uparrow}{4d}\ \frac{}{4d}\ \frac{}{4d}\ \frac{}{4d}$

(d) Potassium (K) **ion** (either orbital or spdf notation – your choice – but not noble gas)

K^+ 18e⁻ $1s^2 2s^2 2p^6 3s^2 3p^6$

or

$\frac{\uparrow\downarrow}{1s}\ \frac{\uparrow\downarrow}{2s}\ \frac{\uparrow\downarrow}{2p}\ \frac{\uparrow\downarrow}{2p}\ \frac{\uparrow\downarrow}{2p}\ \frac{\uparrow\downarrow}{3s}\ \frac{\uparrow\downarrow}{3p}\ \frac{\uparrow\downarrow}{3p}\ \frac{\uparrow\downarrow}{3p}$

7. What volume of nitrogen gas is produced when 0.0831 mol sodium azide (NaN_3, 65.0099 g/mol) is decomposed at 673 K and 0.987 atm? $2\ NaN_3\ (s) \rightarrow 2\ Na\ +\ 3\ N_2$

not a gas!

$$0.0831\ mol\ NaN_3 \left(\frac{3\ mol\ N_2}{2\ mol\ NaN_3}\right) = 0.12465\ mol\ N_2$$

Answer: 6.98 L

$$PV = nRT$$

$$(0.987\ atm)(V) = (0.12465\ mol)\left(0.0821\ \frac{L\cdot atm}{mol\cdot K}\right)(673\ K)$$

$$V = 6.978\ L$$

8. Calculate the following:

$$356\ nm \left(\frac{1\ m}{10^9\ nm}\right) = 3.56 \times 10^{-7}\ m$$

(a) The energy of light with a wavelength of 356 nm.

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J/s)(3.00 \times 10^{8}\ m/s)}{3.56 \times 10^{-7}\ m}$$

$$E = 5.5837 \times 10^{-19}\ J$$

Answer: $5.58 \times 10^{-19}\ J$

(b) The energy change when an electron jumps from the third to the fifth energy level. Is this energy emitted or absorbed?

$$E = -R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$= -2.18 \times 10^{-18}\ J\left(\frac{1}{5^2} - \frac{1}{3^2}\right)$$

$$= -2.18 \times 10^{-18}\ J\ (0.04 - 0.1111)$$

$$= 1.5502 \times 10^{-19}\ J$$

Answer: $1.55 \times 10^{-19}\ J$

emitted or absorbed? absorbed