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Sample Question Solutions for the Breaking Bonds Round Test

Physical Properties – Easy

1. What are the dominant intermolecular forces for each of the following molecules?

Choose between London Dispersion Forces, Covalent Interactions, Gravitational Forces, Dipole – Induced Dipole Forces, Dipole – Dipole Forces, and Hydrogen Bonds

a. Liquid Nitrogen:

London Dispersion Forces________________

b. Water:

Hydrogen Bonds________________________

c. Carbon Dioxide:

London Dispersion Forces________________

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Kinetics – Easy

2. Write the rate law for the following reaction given the following details. Assume the rate constant is 1.

$$2\,A + 5\,B + 3\,C \rightarrow 2\,AB_2C + BC$$

You know the reaction is:

- first order with respect to A
- second order with respect to B
- zeroth order with respect to C

rate = k[A][B]^2

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Stoichiometry – Medium

3. The Haber Reaction is a reaction used to synthesize ammonia (NH_3), which is a common component of fertilizers. Consider the **unbalanced** Haber Reaction below. You are given 8.74 g of N_2(g) and 31.47 L of H_2(g) at STP (0 °C, 1 atm). Assuming the reaction goes to completion, how many moles of the excess reagent will be left over? Assume ideal gas behavior.

Unbalanced Haber Reaction: $H_2(g) + N_2(g) \rightarrow NH_3(g)$

$3H_2 + 1N_2 \rightarrow 2NH_3$

$$\frac{8.74\ g\ N_2}{1} * \frac{1\ mole\ N_2}{28.013\ g\ N_2} = 0.312\ moles\ of\ N_2\ \rightarrow Limiting\ Reactant$$

$$\frac{31.47L\ \ H_2}{1} * \frac{1\ mole\ H_2}{22.4\ L\ H_2} = 1.4\ moles\ of\ H_2\ \rightarrow Excess\ Reactant$$

0.312 moles of N_2 used

(0.312 moles)*(3) = 0.936 moles H_2 *used*

1.4 – 0.936 = 0.464 moles H_2 remaining

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Redox - Medium

4. Hydrogen peroxide decomposes spontaneously under standard conditions. Below is the **unbalanced** equation for the decomposition of hydrogen peroxide.

$$H_2O_2 \rightarrow H_2O + O_2$$

a. List the oxidation states of each element.

H in H_2O_2 is: +1
O in H_2O_2 is: -1
H in H_2O is: +1
O in H_2O is: -2
O in O_2 is: 0

Write the balanced oxidation and reduction **half reactions** in an **acidic medium**.

Reduction: **H2O2 + 2 H+ + 2 e- → 2 H2O** or **H2O2 + 2 H3O+ + 2 e- → 4 H2O**

Oxidation: **H2O2 → + O2 + 2 e- +2 H+** or **H2O2 + 2 H2O → + O2 + 2 e- + 2 H3O+**

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Acid-Base Equilibrium – Hard

5. The ocean floor in Krypton consists of hydrothermal vents and high water pressure. Under temperatures of 150 °C and pressures of about .47 MPa, the self-ionization of water has a pK_w of 11.64.
An unknown, diprotic acid, H_2A, may be released from these hydrothermal vents. The concentration of the acid in the area is 0.01 M. Calculate the pH of the surrounding region given the following information about the acid.

- K_{a1} = 4.5x10-7
- K_{a2} = 4.7x10-11

	H_2X	$\rightarrow$	HX	H^+
Initial	.01		0	sqrt($10^{-11.64}$)
Change	-x		+x	+x
Final	.01-x		+x	1.5136*10^-6 + x

(x)(1.5136*10^-6 + x) / (.01-x) = 4.5x10^-7

x = 6.611×10^{-5}

$H^+ = 1.5136*10^{-6} + 6.611 \times 10^{-5}$ = 6.7621x10^-5

pH =-log(H^+) = -log(6.7621x10^-5) = 4.17

pH = 4.17

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Thermodynamics - Hard

6. 31.4 g of ice is added to 100 g of water that is at 66.60 °C in a constant-pressure calorimeter. At the instant when all the ice has melted, the final temperature of the water is 23.40 °C. Given that the specific heat, C, of water is 4.18 J/g°C, what is the experimental value for the specific heat of fusion, ΔH_f, of ice? Report your answer in kilo-joules per mole.

(100g)(66.6°C -23.4°C)(4.18K/g°C) =18057.6Joules gone to melting the ice

(18507.6J) *(18g/mol) / (31.4g) = 10351.5 Joules/mol

10.35 kJ/mole