CHM−101 Exam 2 Summer 2009
NAME ____________KEY_________________

1. Ethylene glycol, the primary component of most antifreezes, is 38.7% C, 9.7% H, and 51.6% O by mass. The empirical formula of ethylene glycol is: **(determination of empirical formula from weight %)**

a. CHO [✓ b. CH_3O] c. $C_3H_9O_3$ d. C_4HO_5 e. $C_3H_{10}O_3$

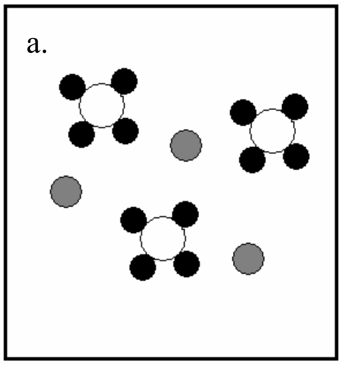
$$\text{mol C} = \frac{38.7\text{ g}}{} \left| \frac{1\text{ mol C}}{12.0\text{g}} \right. = \frac{3.225\text{ mol C}}{} \left| \frac{}{3.225} \right. = 1.00$$

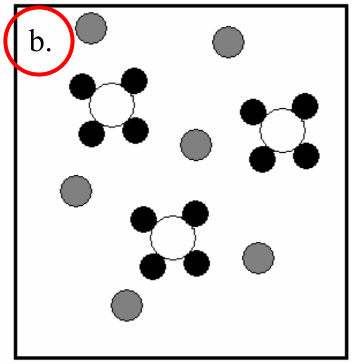
$$\text{mol H} = \frac{9.7\text{ g}}{} \left| \frac{1\text{ mol H}}{1.00\text{g}} \right. = \frac{9.7\text{ mol H}}{} \left| \frac{}{3.225} \right. = 3.01$$

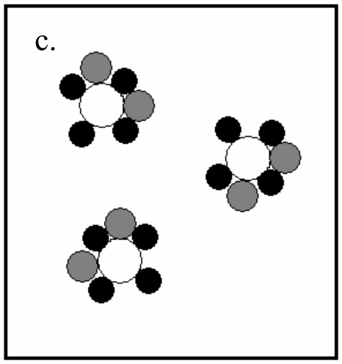
$$\text{mol O} = \frac{51.6\text{ g}}{} \left| \frac{1\text{ mol O}}{16.0\text{g}} \right. = \frac{3.225\text{ mol O}}{} \left| \frac{}{3.225} \right. = 1.00$$

Numbers determined above are the subscripts in the empirical formula: CH_3O

2. In the nanoscale diagrams below, ◍ stands for sodium ions, ○ represents sulfur atoms and ● represents oxygen atoms. Which diagram represents an aqueous solution of sodium sulfate (water molecules are not shown)? **(electrolytes – strong, weak and non-electrolytes)**


a.


[✓ b.]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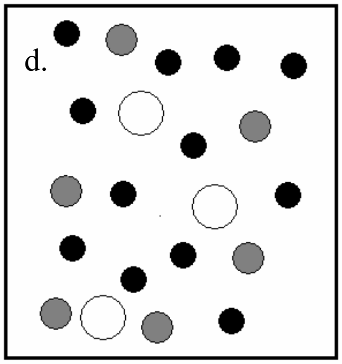
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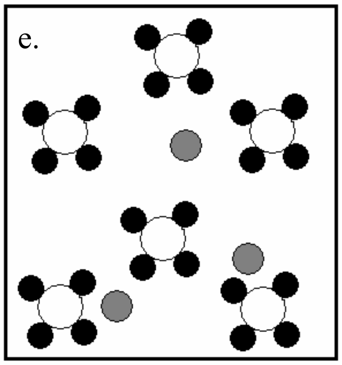

e.

Sodium sulfate is an ionic compound composed of two sodium ions (Na^+) and a SO_4^{2-}. When it dissolves in water, it dissociates into these three ions.

3. $Ba_3(PO_4)_2$ is ___________in water and NH_4Br is __________ in water.**(solubility of ionic compounds)**

a. insoluble, insoluble   b. soluble, soluble   c. soluble, insoluble   [✓ d. insoluble, soluble]

e. more information is needed than is supplied by solubility table

From solubility table, $Ba_3(PO_4)_2$ is insoluble and NH_4Br is soluble.

4. If an aqueous solution of NH_4Br is mixed with an aqueous solution of Na_2SO_4:

a. there are no spectator ions because both products are insoluble
b. NH_4^+ and SO_4^{2-} are spectator ions
c. Na^+ and Br^- are spectator ions
d. NH_4^+ and Na^+ are spectator ions
[✓ e.] all four ions (NH_4^+, Na^+, Br^-, and SO_4^{2-}) are spectator ions because no reaction occurs

There is no reaction because it would produce NaBr and $(NH_4)_2SO_4$. Both of these are soluble so they would exist as their dissociated ions in solution just as the reactants do.

5. Which of the following compounds are nonelectrolytes? **(electrolytes – strong, weak and non-electrolytes)**

a. strong acids   b. weak acids   c. strong bases   [✓ d. sugars]   e. salts

Strong acids, strong bases, and salts are all strong electrolytes. Weak acids are weak electrolytes. Sugars must be the nonelectrolytes.

6. The correct name for HBr is ______________________and correct formula for sulfurous acid is ________.

a. bromic acid, H_2SO_4 b. hydrobromic acid, H_2SO_4 [✓ c. hydrobromic acid, H_2SO_3]

d. bromous acid, H_2SO_3 e. hydrobromic acid, H_2S

(acid nomenclature) rules on page 64 of text (and from notes)

7. What mass of $C_6H_{12}O_6$ (MW = 180) is needed to prepare 5.00 L of a 0.100 M solution of $C_6H_{12}O_6$?

a. 9.00 g   b. 9.00 x 10^3 g   c. 3.60 g   [✓ d. 90.0 g]   e. 1.11 x 10^{-4} g

(Molarity)	? g $C_6H_{12}O_6$ =	1.00 mol $C_6H_{12}O_6$	1 L	500 mL	180 g	= 90.0 g
		1 L	1000 mL		1 mol $C_6H_{12}O_6$	
Step			1	2	3	

Steps 1 and 2 (M x V, and volume units conversion) give moles of $C_6H_{12}O_6$ contained in the volume and then FW used to convert moles to g.

8. What is the **ammonium** ion concentration in a solution prepared by dissolving 4.53 g of $(NH_4)_2SO_4$ (FW = 132) in enough water to make 100 mL of solution? **(molarity and electrolytes)**

a. 1.37 M   b. 1.03 M   [✓ c. 0.686 M]   d. 0.343 M   e. 0.0453 M

M NH_4^+	= mol NH_4^+	= 4.53 g $(NH_4)_2SO_4$	1 mol $(NH_4)_2SO_4$	**2 mol** NH_4^+		1000 mL	= 0.686 M
	L solution		132 g $(NH_4)_2SO_4$	**1 mol** $(NH_4)_2SO_4$	100 mL	1 L	
step			1	**2**	3	4	

Step 2 comes from knowing that $(NH_4)_2SO_4$ is a strong electrolyte in water. Every mole of $(NH_4)_2SO_4$ that dissolves dissociates into a mole of sulfate ions and 2 moles of ammonium ions. (Steps do not have to be done in this order).

9. What mass of CO_2 (MW = 44.0) is produced by complete reaction of Na_2CO_3 with 100.0 mL of 0.200 M HCl? **(molarity and equation stoichiometry)**

$$Na_2CO_3(aq) + 2\,HCl(aq) \longrightarrow 2\,NaCl(aq) + H_2O(l) + CO_2(g)$$

[✓ a. 0.440 g]   b. 44.0 g   c. 0.880 g   d. 4.40 g   e. 11.0 g

? g CO_2 =	0.200 mol HCl	100.0 mL	1L	1 mol CO_2	44.0 g CO_2	= 0.440 g
	1 L		1000 mL	2 mol HCl	1 mol CO_2	
step			1	2	3	

Determine moles of HCl from volume and concentration information (step 1), then use the stoichiometry in equation to determine moles of CO_2 produced (step 2), and finally use MW of CO_2 to determine g CO_2.

10. If 50.0 mL of a concentrated solution of NaI is to be used to prepare 2.00 L of a 0.0500 M NaI solution, what molarity does the concentrated solution need to be? **(Dilution)**

[✓ a. 2.00 M]   b. 0.500 M   c. 1.25 M   d. .00200 M   e. 0.00125 M

$M_{conc} \times V_{conc} = M_{dilute} \times V_{dilute}$; ? M =	M_{dilute}	V_{dilute}	= 0.0500M	2.00 L	1000 mL	= 2.00 M
		V_{conc}		50.0 mL	1 L	

11. Nitroglycerine (MW = 227) decomposes according to the equation below. The enthalpy change for this reaction is -5.72×10^3 kJ.

$$4\,C_3H_5(NO_3)_3(l) \longrightarrow 12\,CO_2(g) + 10\,H_2O(l) + O_2(g) + 6\,N_2(g)$$

How many grams of carbon dioxide would be produced if enough nitroglycerine decomposes to produce 500 kJ of heat? **(heat change and equation stoichiometry)**

a. 3.85 g   [✓ b. 46.2 g]   c. 0.0238 g   d. 44.0 g   e. 1.05 g

? g C =	–500 kJ	12 mol CO_2(g)	44.0 g	= 46.2 g
		–5.72 x 10^3 kJ	1 mol CO_2(g)	
step		1	2	

Step 1 uses the equation stoichiometry. The signs are not needed. Step 2 used to convert the number of moles CO_2 produced to the number of grams.

12. Given the equations below with their associated enthalpy changes,

(1) $2\ C_2H_6(g) + 7\ O_2(g) \longrightarrow 4\ CO_2(g) + 6\ H_2O(l)$ $\Delta H_1 = -3119.4$ kJ

(2) $C_2H_4(g) + 3\ O_2(g) \longrightarrow 2\ CO_2(g) + 2\ H_2O(l)$ $\Delta H_2 = -1410.9$ kJ

(3) $H_2(g) + ½\ O_2(g) \longrightarrow H_2O(l)$ $\Delta H_3 = -285.8$ kJ

calculate the enthalpy change (in kJ) for the following reaction **(Hess's Law)**

(4) $C_2H_6(g) \longrightarrow C_2H_4(g) + H_2(g)$ $\Delta H_4 = ?$

a. – 4816.1 kJ b. 4816.1 kJ c. – 1422.7 kJ d. 1422.7 kJ [✓ e. 137.0 kJ]

Multiply equation (1) and ΔH_1 by ½; reverse equation (2) and ΔH_2; and reverse equation (3) and ΔH_3: then add the results together to get equation 4 and ΔH_4 = 137.0 kJ

13. Which of the following processes is endothermic? **(general knowledge of exothermic and endothermic processes)**

a. $NH_3(g) \rightarrow NH_3(l)$ b. $CO_2(g) \rightarrow C(s) + O_2(g)$ c. $CaBr_2(s) \rightarrow Ca(s) + Br_2(l)$

[✓ d. both b and c] e. both a and c

Phase changes from s to l, l to g, and s to g are all endothermic and the reverse processes are exothermic, so a is exothermic. Answers b and c are the reverse of exothermic reactions (combustion and metal reacting with nonmetal) so both are endothermic.

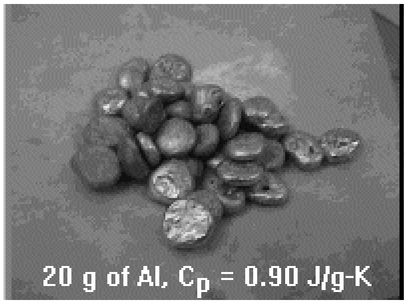
14. Calculate the kinetic energy (in J) of an object that weighs 45.0 kg that is traveling at a velocity of 1000 m/s.

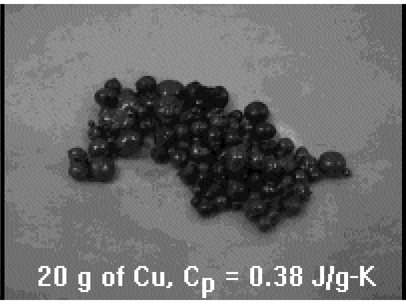
a. 1.01 J b. 22.5 J c. 2.25 x 10^4 J d. 4.50 x 10^4 J [✓ e. 2.25 x10^7 J]

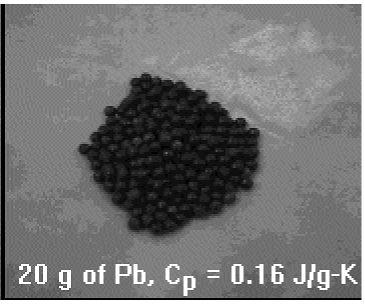
? kJ =	$\frac{1}{2}$ mv^2 =	1 45.0 kg	$(1000\ m/s)^2$	1 J	= 2.25 x 10^7 J
		2		1 kg m^2/s^2	
step		1	1	2	

(Kinetic Energy) Step 1 is determination of numerical answer and step 2 is just a reminder that kg and m/s are the correct units for Joules.

Use the information presented below to answer questions 15 and 16.







15. Which of these metals would require the **least** heat to raise its temperature from 25 °C to 100 °C? **(Specific heat capacity)**

a. Al b. Cu [✓ c. Pb] d. all require the same amount of heat e. more information needed

For same mass and same ΔT, material with lowest heat capacity requires least amount of heat to raise its T.

16. If 200 Joules of heat are **removed** from the copper (Cu) sample originally at 25.0 °C, the final temperature of the metal will be **(Specific heat capacity)**

a. 51.3 °C b. 35.0 °C c. 15.0 °C [✓ d. − 1.3 °C] e. 26.3 °C

Use $q = c_P(s) \times m \times \Delta T$ and $\Delta T = T_{final} - T_{initial}$. q is written as – 200 J because heat is removed from system.

$$-200\text{ J} = \begin{array}{c|c|c} 0.38\text{ J} & 20\text{ g} & (T_{final} - 25.0\ {}^\circ\text{C}) \\ \hline \text{g}\cdot{}^\circ\text{C} & & \end{array} ; \quad T_{final} = -1.3\ {}^\circ\text{C}$$

17. A 16.8 g sample of granite initially at 0.0 °C was put into a well insulated calorimeter cup which contained 50.0 g of water initially at 25.1 °C. The final temperature of the water in the cup was 23.6 °C. What is the specific heat capacity of the granite? The specific heat capacity of water is 4.18 J/g°C. **(specific heat capacity, heat capacity lab)**

a. 25.0 J/g°C b. 1.27 J/g°C [✓ c. 0.791 J/g°C] d. 0.176 J/g°C e. 0.744 J/g°C

$$-\,q_{\text{water}} = q_{\text{granite}}$$

$$\begin{array}{c|c|c} -\,4.18\text{ J/g}^\circ\text{C} & 50.0\text{ g} & (23.6–25.1)\ {}^\circ\text{C} \\ \hline & & \end{array} \quad \begin{array}{c|c|c} \text{s or } c_{P\ \text{granite}} & 16.8\text{ g} & (23.6– 0.0)\ {}^\circ\text{C} \\ \hline & & \end{array}$$

$$0.791\text{ J/g}^\circ\text{C} = \text{s or } c_{P\ \text{granite}}$$

18. Determine the enthalpy change (in kJ) for the following reaction using data from the table of standard thermodynamic values. **(using ΔH_f's to calculate $\Delta H_{reaction}$)**

$$H_2(g) + O_2(g) + 2\,NO_2(g) \longrightarrow 2\,HNO_3(g)$$

a. 335.2 kJ [✓ b. −335.2 kJ] c. 167.6 kJ d. −167.6 kJ e. −479.8 kJ

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

$$\Delta H^o = \left(2\text{ mol } HNO_3(g)\left|\frac{-134.3\text{ kJ}}{1\text{mol}}\right.\right) - \left(2\text{ mol } NO_2(g)\left|\frac{33.3\text{kJ}}{1\text{ mol}}\right.\right) = -335.2\ \text{kJ}$$

19. A, B and C have the following solubilities in 100 mL of water at 25°C, respectively: 25 g, 30 g, and 62 g. If 25 g of each are added to 50 mL of water, which will completely dissolve? **(fractional crystallization lab)**

a. A b. B [✓ c. C] d. A and B e. B and C

	A	B	C
solubility in 100 mL H_2O	25 g	30 g	62 g
solubility in 50 mL H_2O	12.5 g	15 g	31g
amount added to 150 mL	25 g	25 g	25 g
amount not dissolved	12.5 g	10 g	0 g (could dissolve 6 g more)

20. An unknown is colorless, odorless, and neutral. It forms precipitates when reacted with each of the halide ions Cl^-, Br^-, and I^-. Which of the following could it be? **(exchange reactions lab)**

a. $HClO_4$ [✓ b. $Hg_2(NO_3)_2$] c. $CoSO_4$ d. K_2CrO_4 e. NH_4OH

Answer cannot be c or d because $CoSO_4$ is red and K_2CrO_4 is yellow. It cannot be a, because $HClO_4$ is a strong acid. It cannot be e because NH_4OH will have an ammonia odor. It has to be b. Could also go straight to b as answer because mercury(I) ion is only cation among answers that forms precipitates with halide ions.

21. Calculate ΔE of a system when it releases 113 kJ of heat to the surroundings and it does 39 kJ of work on the surroundings. **(transfer of heat & work into & out of a system)**

[✓ a. −152 kJ] b. 152 kJ c. 0 kJ d. −74 kJ e. 74 kJ

If heat is released to surroundings from system then q = −113 kJ (system loses heat). Because system does work on surroundings, w = −39 kJ.

$$\Delta E = q + w = -113\text{ kJ} + -39\text{ kJ} = -152\text{kJ}$$

Soluble Compounds	**Exceptions**

Salts containing group 1A cations and NH_4^+	
Salts of Cl^-, Br^-, and I^-	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Salts of F^-	those formed with Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}
Salts of NO_3^-, ClO_3^-, ClO_4^-, and $C_2H_3O_2^-$	
Salts of SO_4^{2-}	those formed with Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Compounds	**Exceptions**
Salts of CO_3^{2-}, PO_4^{3-}, $C_2O_4^{2-}$, CrO_4^{2-}, S^{2-}, OH^-, and O^{2-}	Salts of NH_4^+ and group 1A cations

Standard Thermodynamic Values

Compound	ΔH°_f (kJ/mol)	ΔG°_f (kJ/mol)	S° (J/mol·K)
$NO(g)$	90.2	86.6	211
$NO_2(g)$	33.3	51.3	240
$HNO_3(aq)$	–206.6	–110.5	146
$HNO_3(g)$	–134.3	–73.9	266
$O_2(g)$	---	---	205
$HCl(g)$	–92.3	–95.3	187
$HF(g)$	–268.6	–270.7	174
$F_2(g)$	---	---	203
$Cl_2(g)$	---	---	223
$H_2(g)$	---	---	131

Useful Information

General Formulas

$$w = F \times d \qquad E_k = \frac{1}{2}mv^2 \qquad \Delta E = E_{\text{final}} - E_{\text{initial}} \qquad \Delta E = q + w \qquad \Delta H = q_P$$

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

$$c_P = \frac{q}{m \text{ x } \Delta T} \qquad q = c_P \text{ x } m \text{ x } \Delta T$$

Conversion Factors

$$°C = \frac{5}{9}(°F - 32) \qquad K = °C + 273 \qquad 1 \text{ amu} = 1.66054 \times 10^{-24} \text{ g}$$

1 in = 2.54 cm *1 lb = 453.6 g* *1 cal = 4.184 J*

1 Cal = 1000 cal = 4.184 kJ

Constant

$N_A = 6.02 \times 10^{23}$