

REFERENCE SHEET FOR ACDA5014 ADVANCED CHEMISTRY QUIZ #1

ANSWERS

PERIODIC CHART OF THE ELEMENTS																		INERT GASES		
IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA						
1 H 1.00797														1 H 1.00797	2 He 4.0026					
3 Li 6.939	4 Be 9.0122														5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
11 Na 22.9898	12 Mg 24.312														13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80			
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30			
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)			
87 Fr (223)	88 Ra (226)	*89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)									

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
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† Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)
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PHYSICAL CONSTANTS:

$c = 3.0 \times 10^8 \text{ m/s}$ (speed of light)
 $R_H = 3.29 \times 10^{15} \text{ s}^{-1}$ (Rydberg constant)
 $h = 6.6 \times 10^{-34} \text{ Js}$ (Plank's constant)
 $e = 1.602 \times 10^{-19} \text{ C}$ (charge of electron)
 $1 \text{ amu} = 1.66 \times 10^{-24} \text{ kg}$ (atomic mass unit)
 6.02×10^{23} Avogadro's number
 $R = 0.0821 \text{ L-atm/mol-K}$

USEFUL EQUATIONS:

$g = n \times MM$
 $M = \text{mol} / v$
 $m = \text{mol of solute} / \text{kg solvent}$
 $\chi = (\text{moles of solute}) / (\text{total number of moles})$
 $c = v \times \lambda$
 $E = h \times v$
 $v = R_H ((1/n_1^2) - (1/n_2^2))$
 $\% \text{ yield} = (\text{actual yield} / \text{theoretical yield}) \times 100\%$

ACDA5014 ADVANCED CHEM 1 QUIZ 1

NAME _____ DATE: March 01, 2022

1. **(10 points)** Indicate whether each of the following statements is true or false:

T F

☒ One mole of carbon-12 weighs exactly 12 grams.

☒ Intensity of light is directly proportional to the frequency.

☒ A litre is a volume equal to 100 cm³.

☒ There are three d orbitals.

☒ Strontium ion used in pyrotechnics produces green light in fireworks.

☒ X-rays have a longer wavelength than ultraviolet.

☒ Isotopes of the same element always have the same number of protons.

☒ Elements in the same column (family) of the periodic table usually have similar chemical properties.

☒ An ion is formed when a neutral atom gains or loses electrons.

☒ Electrons account for most of the mass of an atom.

2. **(4 points)** Identify each of the following as an element, a compound, a homogeneous mixture or a heterogeneous mixture (no credit for "mixture" as whole answer):

Stainless steel: homogenous mixture.....

Salsa Sauce: heterogenous mixture.....

An iron bar: element.....

Pure sodium chloride:.....compound.....

3. **(3 points)** How many of each type of sub-atomic particles are contained in an atom ^{110}Cd ?

Protons:.....48.....Neutrons: 62.....Electrons:..... 48.....

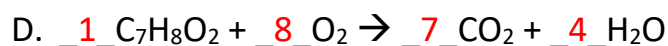
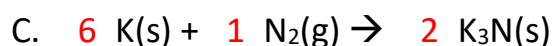
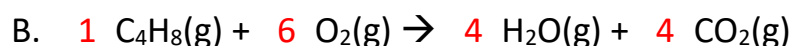
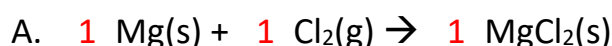
4. **(4 points)** What did Einstein's photoelectric effect experiment prove about the structure of the atom? Answer in no more than 2 sentences.

The photoelectric effect is a phenomenon where electrons are emitted from the metal surface when the light of sufficient frequency is incident upon.

Electrons can absorb or emit energy of a certain value

Electrons occupy levels in the atom of certain energy only.

5. **(8 points)** Balance the following equations. Do not leave spaces blank. Write "1" to indicate a single unit of a species.



6. **(5 points)** How many nitrogen atoms are there in 30.0 g of N_2O_4 . Give your answer in individual atoms, not moles.

1 mol of N_2O_4 has mass of 92.0 g so 30.0 g of N_2O_4 is the mass of (30.0 g/92.0 g/mol) 0.326 mol N_2O_4

One mol of N_2O_4 molecules provides 2 moles of N atoms, so 0.326 mol N_2O_4 provides (2 x 0.326) 0.652 mol of N atoms

1 mole of N atoms contains 6.022×10^{23} atoms of N so 0.652 mol N contains (0.652 mol N x 6.022×10^{23} N atom/mol N) **3.93×10^{23} N atoms**

7. (5 points) 1.07g of solid $\text{Ca}(\text{NO}_3)_2$ are dissolved in enough water to make 452.1 mL of solution. Calculate the molar concentration of $\text{Ca}(\text{NO}_3)_2$ in the solution.

Molarity is $M = \text{mol solute} / \text{v solution}$ with the unit of **mol/L**

$\text{Ca}(\text{NO}_3)_2$ is the solute. It has a molar mass of 164.0 g and 1.07 g of $\text{Ca}(\text{NO}_3)_2$ corresponds to (1.07 g/164.0 g/mol) **0.0065 mol $\text{Ca}(\text{NO}_3)_2$**

Volume of solution is 452.1 mL = **0.4521 L**

$M = \text{mol} / V = 0.0065 \text{ mol } \text{Ca}(\text{NO}_3)_2 / 0.4521 \text{ L} = \mathbf{0.0144 \text{ mol/L}}$

8. (14 points) Answer the following questions.

A. (9 points) Write the full and shorthand electronic configuration of each species. For the shorthand notation show the electrons in orbitals.

Na: 11 valence electrons

full electron configuration: **$1s^2 2s^2 2p^6 3s^1$**

shorthand electron configuration: **$[\text{Ne}] 3s^1$** 

Cu: 29 valence electrons

full electron configuration: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ full subshell**

shorthand electron configuration: **$[\text{Ar}] 4s^1 3d^{10}$**  

Co^{2+} : Co has 27 valence electrons, Co^{2+} has 2 electrons less = 25 electrons

full electron configuration: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$**

shorthand electron configuration: **$[\text{Ar}] 4s^2 3d^5$**  

B. (2 points) How many unpaired electrons are there in a sulfur atom?

S has 16 valence electrons **$[\text{Ne}] 3s^2 3p^4$**  

There are **2 unpaired electrons**

C. (3 points) Circle the answer that correctly arranges the species in order of increasing ionization potential:

Cl, Ar, K^+ K^+ , Ar, Cl K^+ , Cl, Ar Cl, K^+ , Ar

9. (8 points) An electron in the hydrogen atom moves from the $n=5$ state to the $n=3$ state.

A. (4 points) Calculate the frequency of the light related to this transition

$$\nu = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = 3.29 \times 10^{15} \text{ s}^{-1} \left(\frac{1}{5^2} - \frac{1}{3^2} \right) = 3.29 \times 10^{15} \text{ s}^{-1} \left(\frac{1}{25} - \frac{1}{9} \right)$$

$$\nu = (-) 2.34 \times 10^{14} \text{ Hz (1/s, s}^{-1}\text{)}$$

B. (3 points). Calculate the energy associated with this transition.

$$E = h \times \nu = 6.6 \times 10^{-34} \text{ J-s} \times (-) 2.34 \times 10^{14} \text{ 1/s}$$

$$E = - 1.54 \times 10^{-19} \text{ J the negative sign means that energy is ...}$$

C. (1 point) Is the energy absorbed or emitted?

... emitted

10. (6 points) For each of the following molecules, give the name of the molecular geometry, give an approximate value for the specified angle (in degrees), and indicate whether the molecule has a permanent dipole. If an angle is a little smaller than some value, you must specify "greater than" or "less than" the closest angle you can name.

A. **NF₃** MOLECULAR SHAPE: trigonal pyramidal

F-N-F BOND ANGLE: less than 109.5 PERMANENT DIPOLE? **Y** / N

B. **CH₂S** MOLECULAR SHAPE: trigonal planar

H-C-S BOND ANGLE: 120 PERMANENT DIPOLE? **Y** / N

11. (6 points) Answer each of the following:

A. Arrange the following atoms in order of increasing electronegativity: Si S O Na

Na < Si < S < O

B. Arrange the following species in order of increasing radius: F O²⁻ Li C.

Li < C < F < O²⁻

C. Arrange the following species in order of increasing ionization potential (if an ion is specified, use the ionization potential of the ion, not the parent atom): F⁻ Ne Na

Na < F⁻ < Ne

12. (6 points) The radio station 92.1 FM broadcasts at a frequency of 9.21×10^7 Hz (92.1 MHz). Calculate the wavelength of the broadcast, and the energy of one photon.

Wavelength (λ) and frequency (ν) are related through c , speed of light: $c = \lambda \times \nu$ so $\lambda = c / \nu$

ν in this problem equals 9.21×10^7 Hz so $\lambda = (3 \times 10^8 \text{ m/s}) / (9.21 \times 10^7 \text{ s}^{-1}) = 3.26 \text{ m}$

$E = h \times \nu = 6.62 \times 10^{-34} \text{ J-s} \times 9.21 \times 10^7 \text{ 1/s} = 6.097 \times 10^{-26} \text{ J}$

13. (5 points) Calculate the percentage yield of the following reaction $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$ if 29.5 g of CH_4 reacts with an excess of oxygen and produces 68.0 g of CO_2 .

% yield = (actual yield / theoretical yield) x 100%

Actual yield in this reaction is **68.0 g of CO_2** and the theoretical yield can be calculated from the stoichiometry of the reaction: 1 mol of CH_4 produces 1 mol CO_2 . 29.5 g of CH_4 (molar mass 16.0 g/mol) corresponds to $(29.5 \text{ g} / 16.0 \text{ g/mol})$ 1.84 mol CH_4 , the same as the theoretical CO_2 produced. 1.84 mol CO_2 (molar mass 44.0 g/mol) has the mass of $(1.84 \text{ mol } \text{CO}_2 \times 44.0 \text{ g/mol})$ **80.6 g** and it is the **theoretical yield**.

% yield = $(68.0 \text{ g} / 80.6) \times 100\% = 83 \%$

14. (6 points) Calculate the **molality** of 4.91 M NaOH solution that has a density of 1.04 g/mL.

Molality is the number of (moles of solute)/(kg of solvent), **m = mol/kg**.

Assume 1.0 L of SOLUTION and solution consists of solute, NaOH, and solvent.

If the molarity of this solution is 4.91 mol/L, there are **4.91 moles of NaOH** (molar mass 40.0 g/mol) solute in 1.0 L of solution which corresponds to (4.91 mol x 40.0 g/mol) 196.4 g of NaOH.

If density of this solution is 1.04 g/mL, 1.0 L will have a mass of (1000 mL x 1.04 g/mL) 1040 g. **Mass of solvent** is mass of solution minus mass of solute (1040 g – 196.4 g), 843.6 g = **0.8436 kg**

$$m = 4.91 \text{ mol NaOH} / 0.8436 \text{ kg} = 5.82 \text{ mol/kg}$$

15. (5 points) Calculate the mole fraction of each compound in the solution if 35.7 g KBr is dissolved in 1200 g of water (density of water is 1.00 g/mL)

$$\chi = (\text{moles of X}) / (\text{total number of moles})$$

Compound 1: KBr (molar mass 119 g/mol); 35.7 g of KBr corresponds to (35.7 g / 119 g/mol) **0.3 mol KBr**

Compound 2: H₂O (molar mass 18.0 g/mol); 1200 g of H₂O corresponds to (1200 g / 18.0 g/mol) **66.7 mol H₂O**

Total number of moles is 0.3 mol KBr + 66.7 mol H₂O = 67.0 mol

$$\chi_{\text{KBr}} = (\text{moles of KBr}) / (\text{total number of moles}) = 0.3 \text{ mol KBr} / 67.0 \text{ mol} = 0.0045$$

$$\chi_{\text{H}_2\text{O}} = (\text{moles of H}_2\text{O}) / (\text{total number of moles}) = 66.7 \text{ mol H}_2\text{O} / 67.0 \text{ mol} = 0.9955$$

OR 1 – 0.0045 = 0.9955

16. (5 points) Draw the Lewis structure of fulminate ion CNO[–] including the resonance structures. Calculate the formal charge on the carbon atom in each of the resonance structure.

