

Chemistry 221 Hour exam 1
Department of Chemistry, Oregon State University

Name.....**EXAM KEY**.....

30 June 2009

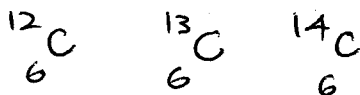
$$h = 6 \times 10^{-34} J \cdot s \quad (1)$$

$$c = 3 \times 10^8 m/s \quad (2)$$

1. (21 pts) Name these:

- (a) Cl_2O_7 dichlorine heptaoxide
- (b) PCl_3 phosphorus trichloride
- (c) SF_6 sulfur hexafluoride
- (d) $AlCl_3$ aluminum (III) chloride
- (e) $CaCO_3$ calcium carbonate
- (f) HNO_3 nitric acid
- (g) $Fe_2(SO_4)_3$ iron(III) sulfate

2. (9 pts) Carbon has three common isotopes, what are they? Designate each by atomic number, and nuclear charge.

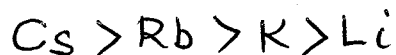


3. (20 pts) Provide the electronic configuration of the following atoms or ions as well as the values of A and Z for its nucleus.

(a) He	$1s^2$	$A=4, Z=2$
(b) N	$1s^2 2s^2 2p^3$	$A=14, Z=7$
(c) Zn^{2+}	$[Ar] 3d^{10}$	$A=65, Z=30$
(d) Al^{3+}	$[Ne]$	$A=27, Z=13$
(e) Ar^-	$[Ar] 4s^1$	$A=40, Z=18$

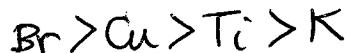
4. (18 pts) Periodic trends

(a) Arrange the atoms, Li, Cs, K, Rb, from highest to lowest covalent radius.



3 pts

(b) Arrange the elements, K, Ti, Cu, Br, from highest to lowest first ionization energy.



3 pts

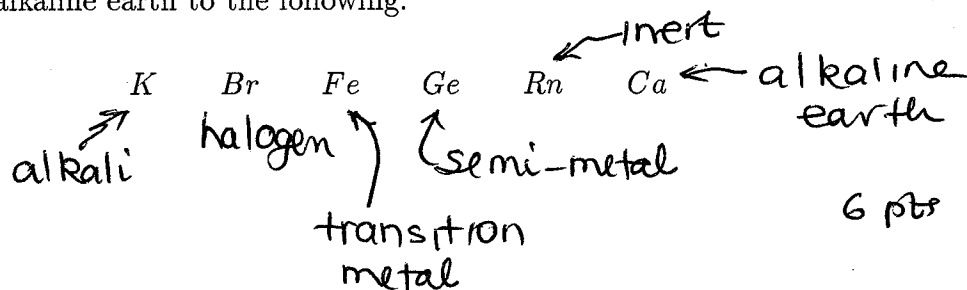
~~(c) Arrange the preceding list in the order of decreasing electron affinity.~~

~~same as the above~~

~~3 pts~~

omit

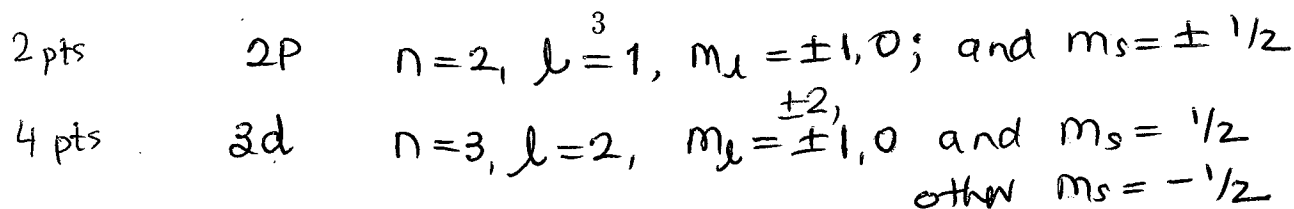
(d) Attach the names: metal, semi-metal, halogen, noble (or inert) gas, alkali metal, alkaline earth to the following:



6 pts

(e) Quantum numbers. What are an acceptable set of quantum numbers for a 2p electron and a pair of 3d electrons

6 pts



7. (16 pts) Rydberg's equation for the absorption and emission wavelengths of an element with nuclear charge Z and with one electron, is

$$\frac{1}{\lambda} = Z^2 R \left(\frac{1}{n_a^2} - \frac{1}{n_b^2} \right) \quad R = 1.0 \times 10^5 \text{ cm}^{-1} \quad n_a < n_b$$

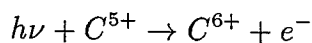
- (a) Calculate the frequency of light which excites a transition from the 2p to the 3d energy level of C^{5+} . $Z = 6$

$$\frac{1}{\lambda} = 36 \cdot 10^5 \text{ cm}^{-1} \left\{ \frac{1}{2^2} - \frac{1}{3^2} \right\} = 5 \times 10^5 \text{ cm}^{-1}$$

$$\frac{1}{4} - \frac{1}{9} = \frac{5}{36}$$

$$\nu = \frac{c}{\lambda} = 3 \times 10^{10} \frac{\text{cm}}{\text{sec}} \cdot 5 \times 10^5 \text{ cm}^{-1} = 15 \times 10^{15} \text{ Hz}$$

- (b) What is the wavelength (in nm) of the photon that ionizes the 1s electron of C^{5+} ? In other words, is responsible for the photochemical reaction



$$\frac{1}{\lambda} = 36 \cdot 10^5 \text{ cm}^{-1} \left\{ 1 - \frac{1}{\infty^2} \right\} = 36 \times 10^5 \text{ cm}^{-1}$$

$$\lambda = \frac{1}{36 \times 10^5} \text{ cm} \approx 2.8 \times 10^{-7} \text{ cm} \approx 28 \text{ \AA} \approx 2.8 \times 10^{-9} \text{ m}$$

5. (8 pts) When a photon with $\lambda = 500 \text{ nm}$ strikes a potassium surface, an electron is ejected. If the threshold energy of the outermost electron in potassium is 2.0 eV ($1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$), what is the kinetic energy of the outgoing electron?

$$h\nu = KE + h\nu_0$$

$$KE = h\nu - h\nu_0 = \frac{h \cdot c}{\lambda} - h\nu_0 = \frac{(6 \times 10^{-34} \text{ J}\cdot\text{s})(3 \times 10^8 \text{ m/s})}{500 \times 10^{-9} \text{ m}} - (2 \text{ eV}) \cdot (1.6 \times 10^{-19} \frac{\text{J}}{\text{eV}})$$

$$KE = \frac{18}{5} \times 10^{-19} - 3.2 \times 10^{-19}$$

$$= 0.4 \times 10^{-19} \text{ J}$$

6. (8 pts) Thermal imaging devices (night vision glasses) are sensitive to radiation with wavelengths ranging from 7000 to 14,000 nm. Being that the peak wavelength of light emitted by a perfect black body obeys

$$\lambda_{\text{peak}} T = 2.9 \times 10^6 \text{ nm} \cdot \text{K}$$

then what is the temperature range over which a thermal body can be detected?

$$T = \frac{2.9 \times 10^6 \text{ nm} \cdot \text{K}}{7 \times 10^3}, \quad T = \frac{2.9 \times 10^6 \text{ nm} \cdot \text{K}}{14,000 \text{ nm}}$$

$$T = \frac{2.9}{7} \times 10^3 \text{ K}, \quad T = \frac{2.9}{14} \times 10^3 \text{ K}$$

$$T = 207 - 414 \text{ K}$$