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 (tri) 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.

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

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^-	$[Ar]4s^1$	$A=40,\ Z=18$

0

4. (18 pts) Periodic trends

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

$Cs > Rb > K > Li$

3 pts

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

$Br > Cu > Ti > K$ 3pts

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

~~same as the above~~ ~~2pts~~

omit

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

K *Br* *Fe* *Ge* *Rn* *Ca*

alkali, halogen, transition metal, semi-metal, inert, alkaline earth

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

2 pts 2P $n=2,\ l=1,\ m_l=\pm1,0;$ and $m_s=\pm 1/2$

4 pts 3d $n=3,\ l=2,\ m_l=\pm2,\pm1,0$ and $m_s=1/2$ other $m_s=-1/2$

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

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

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

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

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

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

(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

$$h\nu + C^{5+} \rightarrow C^{6+} + e^-$$

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

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

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

$h\nu = KE + h\nu_0$

$KE = h\nu - h\nu_0 = \frac{h \cdot c}{\lambda} - h\nu_0 = \frac{(6\times10^{-34}\ J\cdot s)(3\times10^{8}\ \frac{m}{s})}{500\times10^{-9} m} - (2ev)\cdot(1.6\times10^{-19}\ \frac{J}{ev})$

$KE = \frac{18}{5}\times10^{-19} - 3.2\times10^{-19}$

$= 0.4\times10^{-19}\ J$

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

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

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

$T = \frac{2.9\times10^{6}\ nm\cdot K}{7\times10^{3}}$, $T = \frac{2.9\times10^{6}\ nm\cdot K}{14{,}000\ nm}$

$T = \frac{2.9}{7}\times10^{3} K$, $T = \frac{2.9}{14}\times10^{3} K$

$T = 207 - 414\ K$

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