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

Name EXAM KEY

29 June 2010

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

$$c = 3 \times 10^{8} m/s \qquad (2)$$

1. (21 pts) Name these:

   (a) SO_2 sulfur dioxide

   (b) PCl_5 phosphorus pentachloride

   (c) N_2O_3 dinitrogen trioxide

   (d) NH_4OH ammonium hydroxide

   (e) $Fe_2(CO_3)_3$ iron (III) carbonate

   (f) $ZnSO_4$ zinc sulfate

   (g) Na_3PO_4 sodium phosphate

2. (6 pts) Uranium has many isotopes. Designate the number of neutrons and protons in ^{235}U, ^{236}U and ^{238}U.

   235 ⇒ 92 protons, 235−92 = 143 neutrons
   236 ⇒ " " 144 neutons
   238 ⇒ " " 146 neutrons

3. (20 pts) Provide the electronic configuration of the following atoms or ions as well as the values of A (~~atomic~~ mass number) and Z (nuclear charge) for its nucleus. The filling order is:

$$1s < 2s < 2p < 3s < 3p < 3d, 4s < 4p < 4d \cdots$$

		A	Z
(a) Be	$1s^2 2s^2$	9	4
(b) O	$1s^2 2s^2 2p^4$	16	8
(c) Cr^{3+}	[Ar] $3d^3$ or [Ar] $4s^2 3d^1$	52	24
(d) Mg^{2+}	[Ne] or $1s^2 2s^2 2p^6$	24	12
(e) Ar^-	[Ar] 4s	40	18

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4. (10 pts) When a photon with $\lambda = 250$ nm strikes a potassium surface, an electron is ejected. If the threshold energy of the outermost electron in potassium is 2.0 ev (1 ev = 1.6×10^{-19} J), what is the kinetic energy of the outgoing electron?

$$h\nu = KE + h\nu_0 \quad \text{or} \quad h\nu - h\nu_0 = KE$$

8 pts

$$\frac{hc}{\lambda} - h\nu_0 = \frac{(6\times10^{-34}\,J\cdot s)(3\times10^{8}\,m/s)}{250\times10^{-9}m} - 2ev\times1.6\times10^{-19}\frac{J}{ev}$$

$$= \frac{18}{250}\times10^{-17}J - 3.2\times10^{-19}J = (7.2-3.2)\times10^{-19}J$$

$$KE = 4\times10^{-19}J$$

If we double the number of photons striking the surface, how does that change the energy of the outgoing electron?

2 pts

no change

5. (10 pts) The peak in the black-body radiation curve occurs at a wavelength given by the formula

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

The earth radiates the energy because it too is a black-body, and re-emission occurs unless atmospheric species block the heat from escaping. The blocking is done by CO_2 and water vapor. Given that our earth has a temperature of 290K,

(a) calculate λ_{max} and ν for the earth's radiation earth, and

(b) identify its region in the electromagnetic spectrum.

(a) $$\lambda_{peak} = \frac{2.9 \times 10^6 \; nm \cdot K}{290 \; K} = 10^4 \; nm$$

8 pts

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \; m/s}{10^4 \; nm \times \frac{m}{10^9 \; nm}} = 3 \times 10^{13} \; Hz$$

2 pts

(b) IR radiation

/10

6. (13 pts) Rydberg's equation for the absorption and emission wavelengths of an element with nuclear charge Z and with one electron, is

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

5pts

(a) Calculate the frequency of light emitted during a transition from the 3p to the 1s energy level of He^+. $c = \lambda \nu, \ \nu = c/\lambda$

$$\nu = Z^2 c \cdot R \left(\frac{1}{n_a^2} - \frac{1}{n_b^2} \right) = 4 \cdot 3 \times 10^{10} \frac{cm}{sec} \cdot 10^5 \frac{1}{cm} \left(1 - \frac{1}{3^2} \right)$$

$$= 4 \cdot 3 \cdot \frac{8}{9} \times 10^{15} \text{ Hz}$$

$$\nu = \frac{32}{3} \times 10^{15} \text{ Hz}$$

$$10.67 \times 10^{15} \text{ Hz}$$

5pts

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

$$h\nu + He^{1+} \rightarrow He^{2+} + e^-$$

$$\frac{1}{\lambda} = 4 \times 10^5 \frac{1}{cm} \left(1 - \frac{1}{\infty^2} \right) = 4 \times 10^5 \frac{1}{cm}$$

$$\lambda = \frac{1}{4 \times 10^5} cm \times \frac{10^9 nm}{10^2 cm} = \frac{1}{4} \times 10^2 nm = 0.25 \times 10^2 nm$$

$$\lambda = 25 nm$$

3pts

(c) What is the name of the particle remaining after photo-excitation of He^+?

an α particle

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7. (20 pts) Periodic trends

(a) Arrange the atoms, Be, Ra, Ca, Sr, from highest to lowest covalent radius.

3pts

Ra > Sr > Ca > Be
radii

(b) Arrange the elements, Be, Ra, Ca, Sr from highest to lowest first ionization energy.

3pts

Be > Ca > Sr > Ra

6 pts

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

alkali trans. metal

Cs Si Co Ge V I ← halogen

semi-metal

6 pts

(d) Quantum numbers. What are an acceptable set of four quantum numbers for a 2p electron and a 4f electron in the hydrogen atom?

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

4f $n = 4,\ l = 3,\ m_l = \pm 3, \pm 2, \pm 1, 0\ ;\ m_s = \pm 1/2$

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