Chemistry 14-A

Dr. E.R. Scerri
Mid Term
February 6th, 2022

Number	Points available	Points Scored
1	21	
2	14	
3	21	
4	20	
5	16	
6	21	

Total. 113

Name Reimer Grace
Last, First

Signature Grace Reimer

ID # 505687969

Instructions: **This exam has 6 questions plus a periodic table at end of exam. Verify you have the right number of pages before you begin. Write your name on each page.** Ask for help on Zoom if you don't understand a question. **SHOW YOUR WORK!** No credit will be given for an unsubstantiated or illegible answer. Write legibly, use proper units throughout and use significant figures in all answers. **If you exceed the line limit any additional material will not be read by graders**

Good luck!

Possibly useful information:

$h = 6.63 \times 10^{-34}$ J sec (or kg m^2 s^{-1}) $N_O = 6.02 \times 10^{23}$ mol^{-1} $c = 3.00 \times 10^8$ m sec^{-1}

$m_e = 9.11 \times 10^{-31}$ kg 1 a.m.u. = 1.66×10^{-27} kg 1 Å = 10^{-10} m

$g = 9.81$ m/s^2 1 nano meter = 10^{-9} m

1 mole of gas at 1 atmosphere and 298 K occupies 22.47 Liters

$\lambda\nu = c$ $\Delta E = E_f - E_i = \varepsilon_{photon} = h\nu$ $h\nu = h\nu_o$ + K. E.(electron)

$\lambda = \frac{h}{mv}$ $m\Delta v\Delta x = \Delta p\Delta x \geq \frac{h}{4\pi}$

$E_n = -(2.18 \times 10^{-18}\ J)Z^2/n^2$

n - ℓ - 1 = number of spherical (radial) nodes;

ℓ = number of planar nodes;

n-1 = total nodes

Instructions: **This exam has 6 questions plus a periodic table at end of exam. Dierent questions have different numbers of points. Verify you have the right number of pages before you begin. Write your name on each page.**

if you don't understand a question go to Zoom *p*roctoring at the usual lecture Zoom for chem 14A and ask in the chat section.

SHOW YOUR WORK! No credit will be given for an unsubstantiated or illegible answer. Write legibly, use proper units throughout and use significant figures in all answers. Good luck!

Possibly useful information:

12 inches = 1 foot, 2.54 cm = 1 inch.

$h = 6.63 \times 10^{-34}$ J sec $N_O = 6.02 \times 10^{23}$ mol^{-1} $c = 3.00 \times 10^{8}$ m sec^{-1}

$m_e = 9.11 \times 10^{-31}$ kg 1 a.m.u. $= 1.661 \times 10^{-27}$ kg 1 Å $= 10^{-10}$ m

mass (proton) $= 1.672\,62 \times 10^{-27}$kg mass (neutron) $= 1.674\,93 \times 10^{-27}$ kg

1 eV $= 1.602 \times 10^{-19}$ J K.E. $= 1/2mv^2 = p^2/2m$

$F = -\Delta V/\Delta r$ $\lambda\nu = c$ $\Delta E = E_f - E_i = e_{photon} = h\nu$ $h\nu = h\nu_o$ + K. E.(electron)

$\lambda = \frac{h}{mv} = \frac{h}{p}$ $\Delta mv\, \Delta x = \Delta p\, \Delta x \geq \frac{h}{4\pi}$

$E_n = -(2.18 \times 10^{-18}\text{ J})\, Z^2/n^2$

n – ℓ – 1 spherical (radial) nodes; ℓ angular nodes; n – 1 total nodes

n = 1, 2, ... ∞ ℓ = n – 1, ... 0 m_ℓ = $-\ell$ .... 0 .... ℓ

1(a) When 23.51g of compound with formula $C_6H_{10}O_2$ was reacted with 47.6 g of oxygen gas the products were carbon dioxide and water only. Assuming that 34.21 g of carbon dioxide were formed calculate the percentage yield for the formation of this product.

(8)

$23.51\,g\,C_6H_{10}O_2 \mid 1\,mol \mid 114.16\,g = 0.20593\,mol$

$47.6\,g\,O_2 \mid 1\,mol \mid 32\,g = 1.4875\,mol$

mole ratio

$15/2 = \frac{0.20593}{1.4875}$

$7.5 > 0.138$

O_2 is the limiting reagent

$1.4875\,mol\,O_2 \mid 12\,mol\,CO_2 \mid 15\,mol\,CO_2 = 1.19\,mol\,CO_2$

$2C_6H_{10}O_2 + 15O_2 \rightarrow 12CO_2 + 10H_2O$

(theoretical) $\frac{44.01}{1} = 52.372$

(actual) $\frac{34.21}{52.372} \times 100 = 65.3\%$ percentage yield

1(b) Use the ideal gas equation PV = nRT to derive a relationship between

(6)

(i) pressure and temperature,

(ii) volume and pressure and explain any steps taken, while showing your working.

(i) $\frac{P}{t} = \frac{NR}{V}$ Gaylussacs law = pressure and temperature are directly proportional

(ii) $PV = NRT$ According to Boyles law, P and V are inversely proportional

1(c) Why was Mendeleev forced to create a special group to contain elements such as Fe, Co and Ni and also Rh, Ru and Pd ?

(4)

He was forced to create this special groups because they were triads, arranged in order of increasing atomic masses

1(d). Explain how light is able to create an electric current in the photoelectric effect.

(3)

In this effect light is able to create an electric current when light hits materials, this can cause electrons to eject from them. This light produces electricity.

2(a). Why is an atomic mass unit less heavy that either a proton or a neutron? (4)

Because mass is converted into energy in order to stabilize the nucleus, this is called binding energy and causes the A.m.u to not weigh as much as a proton or neutron. They don't have their own binding energy.

2(b). Balance the following equation,

$$2\,C_8H_{18} + 25\,O_2 \;\text{--->}\; 16\,CO_2 + 18\,H_2O \qquad (6)$$

If 35.6 g of C_8H_{18} are in the same container as 0.690 L of oxygen, what volume of carbon dioxide is formed at 1 atmo' and 25^0C. Assume the following atomic masses for this question; C = 12, H = 1 and O = 16

(also assume these values are exact and do not use them to work out significant figures).

mass of C_8H_{18} = 114 g $\quad \frac{35.6\text{ g } C_8H_{18}}{114\text{ g } C_8H_{18}} \left| \frac{1\text{ mol } C_8H_{18}}{} \right. = 0.3122\text{ mol}$ mol ratio

$\frac{2}{25} = \frac{0.8}{1} > \frac{16}{1}$

$0.690\text{ L } O_2 \left| \frac{1\text{ mol } O_2}{22.4\text{ L}} \right. = 0.0308\text{ mol } O_2$

$0.0308\text{ mol } O_2 \left| \frac{16\text{ mol } CO_2}{25\text{ mol } O_2} \right| \frac{22.4}{1\text{ mol } CO_2} = \boxed{0.4422\text{ L } CO_2}$

O_2 is the limiting reagent

2(c) In what respect, if any, is the 32-column periodic table 'better' than the more usual 18-column table? (2)

Its better because of its more natural because it uses atomic numbers as it's foundation which better organizes every element by putting the f-block in its proper place

2(d) What disadvantage, if any, does the long-form representation have? (2)

It is too small to see well and to make it visible it doesn't fit well on paper.

final − initial 5

3(a) This question is about a world in which the laws of chemistry are all the same as on earth except that the Rydberg constant has a different value. Calculate this new Rydberg constant assuming that the energy for **a mole** of Be^{+3} ions to make the transition from n = 6 to n = 3 is 9.60 x 10^5 Joules.

(6) $E_n = -R(Z^2/n^2)$ $E_n = 2.18\times10^{-18}\left(\frac{16}{9} - \frac{16}{36}\right)$

$\frac{9.60\times10^5}{6.022\times10^{23}} = 1.594944\times10^{-18}$

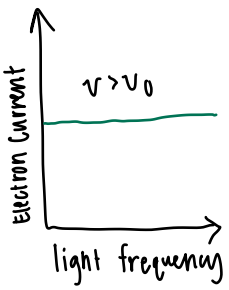
$= 2.18\times10^{-18}\left(\frac{4}{3}\right)$ $R = -\frac{3}{4}\left(1.5941\times10^{-8}\right) = \boxed{1.20\times10^{-18}}$

3(b) By stating which particular orbitals are occupied explain why periods 2 and 3 contain 8 elements, whereas periods 4 and 5 contain 18 of them. (8)

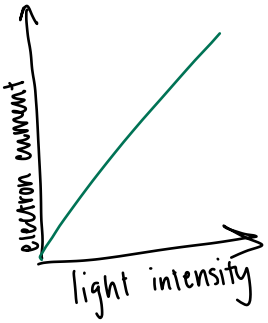
Based on the $2n^2$ rule, the periods 2 and 3 hold up to 8 electrons, while periods 4 & 5 hold up to 18 electrons.

3(c) In the photoelectric effect, how is the number of ejected electrons related to (i) light intensity, (ii) light frequency. Draw graphs to illustrate your answers. (4)

(ii)



(i)



3(d). Calculate the wavelength of a proton moving with a velocity of 1500. m/s (3)

$\lambda = h/mv$ mass $= 1.67262\times10^{-27}$ kg $h = 6.626\times10^{-34}\ \frac{m^2\ kg}{sec}$

$\lambda = (6.626\times10^{-34})/(1.67262\times10^{-23}\times1.5)$

$\lambda = 2.641\times10^{-10} = 0.2641$ nm

1500 = 1.5

4(a) If the electrons in a beam of particles fired at a two-slit arrangement were to behave only as particles, what would the image look like at the screen? (3)

There wouldn't be any diffraction or interference, therefore there would be two light spots.

4(b) Calculate the uncertainty in velocity for a 5.80 g object if the uncertainty in position is +/- 6.00 x 10^{-8} m. (3)

$\Delta mv \Delta p \Delta x > \frac{h}{4\pi}$

$5.80g = 0.0058kg$

$(5.80)\Delta V \geq \frac{6.626\times10^{-34}}{4\pi(12.00\times10^{-8})(0.0058)}$

$\Delta V > 7.58\times10^{-26} m/s$

$(5.80)\Delta v(12.00\times10^{-8}) \frac{6.626\times10^{-34}}{4\pi}$

4(c). Give the ***full and correct configuration*** of the element titanium and also of copper. (4)

$Ti = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$

$Cu = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

4(d). Give the ***abbreviated configurations*** of the +2 ions of chromium and cobalt. (This means you can use noble gas core configurations). (4)

$Cr^{2+} = [Ar]3d^4$ $Co^{2+} = [Ar]\ 3d^7$

4(e) Give the quantum numbers of the 19th electron to be occupied in a scandium atom. (2)

*19th el. scandium enters orbital 4

$n = 4$ $l = 0$ $m = 0$

$n = 4$

$m_s = +1/2$

el. in s orbit. $l = 0, m = 0$

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 3d^1\ 4s^2$

4(f) Give a box diagram for the outer shell electrons of the element tellurium with Z = 52. Also calculate the total spin of this atom. (4)

5s ↑↓ 5p ↑↓ ↑ ↑ 5d

Spin = +|

5a. State how first ionization energy varies on moving from sodium to argon? Explain the overall trend as well as any ***one*** anomaly in the course of the overall trend including the names of the elements concerned.
(4)

The major differences are higher amounts of protons increases in the nucleus as ionization energy moves from sodium to argon. Causing a bigger attraction increasing the ionization energies. Ionization energy in elements increases from left to right starting with Mg and Al because of the valence shell.

5b. Why is the 3d orbital filled before 4s in scandium and why do the final electrons enter the 4s orbital rather than continuing to fill 3d orbitals? Use diagrams as required (in margin). (4)

The 3d orbitals have a lower energy level than 4s so it will the 3d orbital. be filled by the next electron.

5c. How does the Schrodinger model of the atom explain,

(i) The quantization of electron energy (3)

Because an electron has a particular energy values

(ii) The fact that electrons do not collapse into the nucleus (3)

5d. How does the Bohr model explain quantization of electron energy? (2)

He proposes the electron will revolve around the nucleus which is called the angular momentum.

6. Circle one correct answer (3 points each question)

(a) Which of the following statements does not form a part of Bohr's model of hydrogen atom?

- (i) Energy of the electrons in each orbit is quantized
- (ii) The electron in the orbit nearest the nucleus has the lowest energy
- (iii) Electrons revolve in different orbits around the nucleus
- (iv) The position and velocity of the electrons in the orbit cannot be determined simultaneously
- (v) The model provides a good explanation for the existence of the emission spectrum

(b) Which of the following options does not represent ground state electronic configuration of an atom?

- (i) 1s2 2s2 2p6 3s2 3p6 3d8 4s2
- (ii) 1s2 2s2 2p6 3s2 3p6 3d9 4s2
- (iii) 1s2 2s2 2p6 3s2 3p6 3d10 4s1
- (iv) 1s2 2s2 2p6 3s2 3p6 3d5 4s1
- (v) 1s2 2s2 2p6 3s2 3p6 3d6 4s2

(c) The correct set of four quantum numbers for the valence electron of rubidium atom (Z = 37) is

- (i) 5, 0, 0, + 1/2
- (ii) 5, 1, 0, + 1/2
- (iii) 5, 1, 1, + 1/2
- (iv) 6, 0, 0, + 1/2
- (v) 5, 0, 0, - 1/2

(d) The electronic transitions from n = 2 to n = 1 will produce the shortest wavelength in,

- (i) Li^{+2}
- (ii) He^{+}
- (iii) H
- (iv) H^{+}
- (v) Li^{+1}

(e) Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, l = 1 and 2 are, respectively:

- (i) 12 and 4
- (ii) 12 and 5
- (iii) 16 and 4
- (iv) 16 and 5
- (v) 19 and 5

(f) **A 0.66 kg ball is moving with a speed of 100 m/s. Find its wavelength**

- (i) 6.6×10^{-34} m
- (ii) 6.6×10^{-32} m
- (iii) 1.0×10^{-32} m
- (iv) 1.0×10^{-35} m
- (v) 3.0×10^{-35} m

(g) **Which of the following statements about the electron is incorrect?**

- (i) It is a constituent of cathode rays
- (ii) The mass of an electron is equal to the mass of a neutron
- (iii) It is a basic constituent of all atoms
- (iv) It is a negatively charged particle
- (v) The particle was discovered by J.J. Thomson

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (97.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (208.98)	85 At (209.99)	86 Rn (222.02)
87 Fr (223.02)	88 Ra (226.03)	89 Ac (227.03)	104 Rf (261.11)	05 Ha (262.11)	106 Sg (263.12)												

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (144.91)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237.05)	94 Pu (244.06)	95 Am (243.06)	96 Cm (247.07)	97 Bk (247.07)	98 Cf (251.08)	99 Es (252.08)	100 Fm (257.10)	101 Md (258.10)	102 No (259.10)	103 Lr (262.11)