PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATIONS

CH 111 – FOUNDATION CHEMISTRY

FRIDAY 11TH JUNE 2021 – 08:20 AM

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES:

1. Mobile phones are not allowed. Switch off the mobile phones and leave them at the entrance of the exam hall.
2. You will have 10 minutes to read the question paper. You MUST NOT begin writing in the answer book during this time.
3. ANSWER ALL QUESTIONS precisely and to the point
4. Draw the structure and provide the equations WHEREVER REQUIRED.
5. All answers MUST be written on the answer book provided
6. Calculators are permitted in the examination room. Lecture notes, notebooks and text books are NOT allowed.
7. Show ALL workings and calculations in the answer book ONLY.
8. Write your name and student id number clearly on the front page. DO IT NOW.
9. Use the data sheet attached for formulas and equations.

MARKING SCHEME: [100 MARKS]

1. Molarity, limiting reagent and redox reactions

(a). A solution is prepared by dissolving 45.0 g of NaClO in enough water to produce exactly 750 mL of solution. What is the molarity of this solution? [4 marks]

(b). What is the limiting reagent if 76.4 grams of $C_2H_3Br_3$ were reacted with 49.1 g of O_2 to produce Br_2 according to the reaction below?? [6 marks]

$$4C_2H_3Br_3 + 11O_2 \rightarrow 8CO_2 + 6H_2O + Br_2$$

(c). Define oxidizing agents. [2 marks]

(12 marks)

2. Photoelectric effect

(a). Consider electrons ejected from the surface of a metal following irradiation with ultraviolet light.

(i). What is the relationship (if any) between the kinetic energy of the ejected electrons and the wavelength of the UV light? [2 marks]

(ii). What is the relationship (if any) between the kinetic energy of the ejected electron and the intensity of the UV light? [2 marks]

(b). In a photoelectric effect experiment, electrons are ejected from a titanium surface (work function, ϕ = 4.33 eV) following irradiation with UV light. The energy of the incident UV light is 7.2×10^{-19} J per photon.

(i). Calculate the wavelength of the ejected electrons. [4 marks]

(ii). Calculate the wavelength of the incident photons. [5 marks]

3. Orbitals **(13 marks)**

Answer the following questions for 3s, 3p, and 3d orbitals.

(a). Which of these three orbitals has the highest number of angular nodes? [2 marks]

(b). Which of these three orbitals has the largest rmp? [2 marks]

(c). Would a 3s electron feel more or less shielding than a 3p electron? Briefly explain your answer. [4 marks]

(d). Draw the radial probability distribution (RPD) for the electron in a 3s orbital. Label axes, any nodes, and the rmp. [5 marks]

(13 marks)

4. **Binding Energy**

What is the energy of the light absorbed when an electron in a hydrogen atom makes the following transitions: (Give your answers to 3 significant figures).

(b). n = 3 to n = 8;

(c). Draw an energy level diagram for hydrogen, and draw vertical arrows to indicate each of these two electron transitions on the diagram. Label your lines "a", "b", and "c".

5. Multi-electron atoms **(12 marks)**

(a). The binding energy of a calcium 4s electron is -6.1 eV. What is the ionization energy, IE, for this 4s electron (in eV)?

[2 marks]

(b). The binding energy of a calcium 2p electron is -349.7 eV. Calculate the effective nuclear charge experienced by a calcium 2p electron.

[5 marks]

(c). State whether the Z_{eff} value calculated above indicates that this 2p electron is being shielded. Briefly explain your answer. [4 marks]

(11 marks)

6. Ionic bonds

Consider the KF molecule, which has an ionic bond. The bond length is 2.17×10^{-10} m.

(a). Calculate the energy required to dissociate the KF molecule into the ions K^+ and F^-. [6 marks]

(b). The energy required to dissociate KF into neutral atoms is 498 kJ/mol. Given that the first ionization energy for K is 418 kJ/mol, calculate the electron affinity (in kJ/mol) for F. Show your work for all calculations. [3 marks]

7. Periodic Trends

Circle the correct *underlined* answer and briefly explain your choice.

(a). Atomic radius ***decreases*** *increases* as you go across a row in the periodic table.

(b). Low electronegativity is associated with low electron affinity and *high* ***low*** ionization energy.

(c). In general, ionization energy *increases* ***decreases*** down a group in the periodic table. Explain why this is so.

(9 marks)

8. Levis Structure and VSEPR theory

Consider the molecule SF_6:

(a). Draw the most stable Lewis structure for the molecule. Indicate any non-zero formal charge(s).

[4 marks]

(b). Give the SN value of the above molecule

[2 marks]

(c). Give the geometry of the above molecule [2 marks]

(d). Select the expected F-S-F bond angle or angles that exist in SF_6 from the following [2 marks]
<90°; 90°; >90; <109.5°; 109.5°; >109.5°; <120°; 120°; >120°

(10 marks)

9. Gases

(a). Explain how pressure is exerted by gases in a container. [3 marks]

(b). A 100 L Hydrogen storage tank has a mass of 88.67 kg when filled, and 21.35 kg when empty. Calculate the pressure of H_2 in the tank at 25°C using both the ideal gas equation and the van der Waals equation. What is the percentage correction achieved by using the more realistic van der Waals equation? [8 marks]

(11 marks)

DATA SHEET

$c = 2.9979 \times 10^{8}$ m s

$h = 6.6261 \times 10^{-34}$ J s

$N_A = 6.022 \times 10^{23}$ mol^{-1}

$m_e = 9.1094 \times 10^{-31}$ kg

$a_0 = 5.292 \times 10^{-11}$ m

1 amu $= 1.66 \times 10^{-27}$ kg

$R_H = 2.1799 \times 10^{-18}$ J

$\Re = R_H h = 3.2898 \times 10^{15}$ Hz

$$E_n = -\frac{Z^2 R_H}{n^2}$$

$$E_n = -\frac{Z_{eff}^2 R_H}{n^2}$$

1 W = 1 J s^{-1}

1 J = 1 kg m^2 s^{-2}

1 eV = 1.6022×10^{-19} J

$E = h\nu = hc/\lambda$

$c = \nu\lambda$

$KE = (1/2)mv^2$

$p = mv$

$$\lambda = \frac{h}{p}$$

for s wavefunction:

$RPD = 4\pi r^2 \Psi^2 dr$

for $n_f > n_i$.....

$$\nu = \frac{Z^2 R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

for $n_f < n_i$.....

$$\nu = \frac{Z^2 R_H}{h}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$1 \text{ eV} = 1.60218 \times 10^{-19}$ J

$m_e = 9.10939 \times 10^{-31}$ kg

$e = 1.60218 \times 10^{-19}$ C

$U(r) = (z_1 z_2 e^2)/(4\pi\varepsilon_0 r)$

$\varepsilon_0 = 8.8542 \times 10^{-12}$ C^2/(Jm)

Electronegativity = (IE + EA)/2

$$PV = nRT$$

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Van der Waals constants for several common gases

Gas	a (atm L^2 mol^{-2})	b (L mol^{-1})
Ammonia, NH_3	4.170	0.03707
Argon, Ar	1.345	0.03219
Carbon dioxide, CO_2	3.592	0.04267
Helium, He	0.034	0.0237
Hydrogen, H_2	0.2444	0.02661
Hydrogen fluoride, HF	9.433	0.0739
Methane, CH_4	2.253	0.04278