Charles Darwin University

Final Examination

Family Name	
Given Name/s	
Student Number	
Teaching Period	Semester 1, 2018

SCH101 – Chemical Concepts	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

Section A must be answered on the multiple choice answer sheet provided and must be handed in with your answer booklet.
Section B to be answered must be answered in the answer booklet provided.
Formula sheet and periodic table can be found at the end of the exam paper

EXAM CONDITIONS

<u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted	1 x 16 Page Book 1 x Scrap Paper College Multiple Choice Answer Sheet Formula Sheet/s

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

Section A
Multiple Choice Questions

Section B

Short Answer Questions
Answer all 5 questions.
Total No of Marks for this section: 50 marks
This section should be answered in the Answer Booklet provided.
Show <u>all</u> formulas and working.

Marks for each question are indicated. Suggested Time allocation for Section B: 105 minutes

---

Question 1

a) Real gases do not follow all postulates of the Kinetic Theory of gases. State two postulates of the Kinetic Theory of gases that real gases do not obey.

[2 marks]

b) Sodium azide (NaN_3) used in airbags decomposes rapidly during a car crash to produce sodium and nitrogen gas. What mass of sodium azide will inflate a 56.6 L airbag for a car to a pressure of 811 mm Hg at 25 ^{o}C?

(R = 0.08206 L.atm/mol.K)

[3 marks]

c) Iodine has a triple point at 113.5 °C and 0.1191 atm, normal melting point at 113.7 °C, and normal boiling point at 184.3 °C. It's critical point is at 581 °C and115.5 atm. Draw a phase diagram for iodine and clearly label all the transition temperatures. What is its state at 5 atm and 170 °C? [Hint: the graph does not have to be to scale]

[3 marks]

d) Water in a glass tube has lower meniscus while mercury has a higher meniscus. Explain the reasons behind this phenomenon in terms of adhesive and cohesive forces.

[2 marks]

Question 2

a) Most household refrigerators keep food and beverages at or below 4.0°C. The human body has an internal temperature of 37.5°C. Suppose you drink a cup of cold water (250 g) taken from your fridge. How much heat is transferred from your body to the water in order to reach thermal equilibrium? The heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

[3 marks]

b) Calculate ΔH_r for the reaction:

MnO_2 (s) + 2C (graphite) → Mn (s) + 2CO (g)

from the following information:

Mn (s) + O_2 (g) → MnO_2 (s) ; ΔH_r = -520.03 kJ

2C (graphite) + O_2 (g) → 2CO (g) ΔH_r = -221.04 kJ

[3 marks]

c) A glass filled with water absorbs 2.5 x 10^{20} photons of wavelength 1500 nm. How much energy is transferred to the water?

[2 marks]

d) Give a set of four quantum numbers { n, l, m_l, m_s} for a 4d orbital.

[2 marks]

Question 3

a) The magnetic properties of metals can be determined by their electronic configuration. Give the electronic configuration in the form of orbital box diagram for Mn and Zn. Predict whether they are paramagnetic or diamagnetic and explain the reason why.

[3 marks]

b) NH_3 is polar but is CH_4 is non-polar. Using VSEPR theory, predict the geometrical shapes and bond angles of the two molecules and explain the difference in their polarity.

[3 marks]

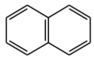
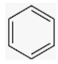
c) Explain in terms of intermolecular forces, whether NH_3 or CH_4 would have a higher boiling point?

[2 marks]

d) The lowest concentration of oxygen that can support aquatic life is about 1.3×10^{-4}mol/L. Given that the partial pressure of oxygen is 0.21atm at sea level, is the solubility of oxygen in seawater adequate to maintain aquatic life?
[Data: henry's law constant, k_H for oxygen = 1.3×10^{3} mol/(L.atm)]

[2 marks]

Question 4

a) Explain why naphthalene () is easily soluble in benzene() than in water.

[2 marks]

b) What is the boiling point of a solution containing 1.52 g naphthalene, $C_{10}H_8$, dissolved in 13.20 g benzene, C_6H_6, ? The boiling point of pure benzene is 80.1°C, and the boiling point elevation constant is 2.53 K kg mol^{-1}.

[2 marks]

c) The osmotic pressure of blood is 7.65 atm at 37 ^{o}C. What mass of glucose ($C_6H_{12}O_6$) is needed to prepare 2.25 L of solution for intravenous injection? The osmotic pressure of the glucose solution must equal the osmotic pressure of blood. (R = 0.08206 L.atm/mol.K)

[2 marks]

d) The following data were collected for the reaction:

$HSO_5^{-}(aq) + ClO_2^{-}(aq) \rightarrow ClO_3^{-}(aq) + SO_4^{2-}(aq) + H^{+}(aq)$, at 25°C.

Experiment No.	$[HSO_5^{-}]$, in mol L^{-1}	$[ClO_2^{-}]$, in mol L^{-1}	Rate, in mol L^{-1} s^{-1}
1	0.050	0.010	1.2 x10^{-5}
2	0.10	0.010	2.3 x 10^{-5}
3	0.20	0.020	9.5 x 10^{-5}

(i) What is the rate equation for the reaction?

(ii) What is the numerical value of the rate constant for the reaction?

(iii) What are the units for the rate constant?

[4 marks]

Question 5

a) At a given temperature, 0.0524 mol $NO_2(g)$ is placed in a 1.00 L flask. After reaching equilibrium, the concentration of $NO_2(g)$ is 3.9 x 10^{-3} M. Calculate the equilibrium constant, K_c for the reaction below?

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

[3 marks]

b) What is the pH of 0.50 M formic acid (HCO_2H)? K_a of HCO_2H = 1.8 x 10^{-4}

[2 marks]

c) What is the pH of the buffer that results when 12 g sodium formate ($NaHCO_2$) is mixed with 250 mL of 0.50 M formic acid (HCO_2H) and diluted with water to 1.0 L? (K_a of HCO_2H = 1.8 x 10^{-4})

[3 marks]

d) The K_{sp} of $Cu(OH)_2$ is 1.6 x 10^{-19} at 25 °C. What is the concentration of $OH^-(aq)$ in a saturated solution of $Cu(OH)_2$ (aq)?

[2 marks]

End of Examination paper

FORMULA SHEET:

Some physical constants that might be useful:

Avogadro's number, $N_A = 6.022 \times 10^{23}$

Universal gas constant, R = 0.08206 L.atm/mol.K = 8.314 J/K.mol = 8.314 L.kPa/K.mol

1 cal = 4.184 J

1 atm= 760 mm Hg = 760 torr =1.013 bar = 101.3 kPa

STP: T = 273.15 K, P = 1.00 atm, V = 22.4 L for 1.00 mol

Rydberg constant, $R = 2.179\text{x}10^{-18}$

Speed of light, $c = 2.998 \times 10^{8}$ m/s

Plank's constant, $h = 6.63 \times 10^{-34}$ Js;

Some equations that might be useful

$$\left(p + \frac{n^2 a}{V^2}\right)(V - nb) = nRT \qquad \sqrt{u^2} = \sqrt{\frac{3RT}{M_r}}$$

$$Q = m \times s \times \Delta T \qquad \ln P_1 - \ln P_2 = -\frac{\Delta_{vap}H^\circ}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$c = \lambda\gamma \qquad E = h\gamma = \frac{hc}{\lambda} \qquad \lambda = \frac{h}{mv}$$

$$E = -2.179\text{x}10^{-18}\left(\frac{Z^2}{n^2}\right) \qquad \Delta x . \Delta v \geqslant \frac{h}{4\pi m}$$

$$s = k_H \text{ x } p \qquad \Delta T_b = i \text{ x} K_b \text{ x } m \qquad \Pi = i \times cRT$$

$$\text{Rate} = k[A]^m[B]^n \qquad k = Ae^{-E_a/RT} \qquad \ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$$

$$t_{1/2} = \frac{0.693}{k}$$

Order	Rate	Integrated Rate Law
0	$r = k[A]^0 = k$	$[A]_t = -kt + [A]_o$
1	$r = k[A]$	$\ln [A]_t = -kt + \ln [A]_o$
2	$r = k[A]^2$	$\frac{1}{[A]_t} = kt + \frac{1}{[A]_o}$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \qquad K_p = K_c\,(RT)^{\Delta ng}$$

$$pH = -log[H_3O^+] \qquad K_a = \frac{[H_3O^+][A^-]}{[HA]} \qquad K_b = \frac{[BH^+][OH^-]}{[B]}$$

$$pK_a = -\log_{10} K_a$$
$$pK_b = -\log_{10} K_b$$

$$\mathrm{pH} = \mathrm{p}K_\mathrm{a} + \log\left(\frac{[\text{conjugate base}]}{[\text{acid}]}\right)$$

Periodic Table of Elements

	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** Hydrogen 1.01																	2 **He** Helium 4.00
2	3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31											13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.87	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)									

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.