Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2019					

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. [Total marks= 50]
Section B to be answered must be answered in the answer booklet provided. [Total marks= 50]
Formula sheet and periodic table can be found at the end of the exam paper

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. 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.

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Section A
Multiple Choice Questions

This section should be answered on the **multiple choice answer sheet** provided. Please ensure that your name and student number is written on the **MCQ answer sheet** and placed in the completed answer Booklet.

1 mark for each question. **Total Marks for this section: 50**

Suggested Time allocation for Section A: 75 minutes

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

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Question 1

a) State Avogadro's law of gases and give the mathematical expression of the law.

[2 marks]

b) Nitroglycerin is a shock-sensitive liquid that detonates by the reaction:

$4C_3H_5(NO_3)_3$ (l) → $6N_2$ (g) + $10H_2O$ (l) + $12CO_2$ (g) + O_2 (g)

Calculate the total volume of product gases at 150 kPa and 100^oC from the detonation of 1.0g of nitroglycerin

[3 marks]

c) 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]

d) The phase diagram of CO_2 has a triple point at –56.6 ^oC and 5.19 atm, and a critical point at 31.0 ^oC and 73 atm. The solid and gas phases are in equilibrium at –78.7 ^oC and 1.00 atm. Sketch a Phase Diagram for CO_2 labelling the above conditions of temperature and pressure. What is its state at 5 atm and 170 °C? [Hint: The graph does not have to be to scale]

[3 marks]

Question 2

a) Calculate the enthalpy of reaction for the synthesis of hydrogen chloride gas:

$H_2\,(g) + Cl_2(g) \rightarrow 2HCl\,(g)$

from the following data:

$NH_3\,(g) + HCl\,(g) \rightarrow NH_4Cl\,(s)$ $\quad \Delta H_r = -176$ kJ

$N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$ $\quad \Delta H_r = -99.22$ kJ

$N_2\,(g) + 4H_2\,(g) + Cl_2(g) \rightarrow 2NH_4Cl\,(s)$ $\quad \Delta H_r = -628.86$ kJ

[3 marks]

b) When heated in a flame, sodium atoms emit light with a frequency of $5.09 \times 10^{14}\ s^{-1}$. What is the wavelength of this radiation in nm?

[2 marks]

c) The energy required to break C-C bonds in a molecule is 348 kJ/mol. Will ultraviolet light of wavelength 420 nm be able to break the bond? Justify your answer by energy calculations.

[2 marks]

d) Mt Kosciuszko in the Snowy mountains range is the highest elevation in Australia. It raises to a height of 2228 m above sea level. At this height, the atmospheric pressure is 77.20 kPa. At what temperature does water boil at the highest point of Mt Kosciuszko? The vapor pressure of water at 373.15 K is 101.3 kPa. ($\Delta_{vap}H°$ for H_2O = 40.7 kJ/mole and R = 8.314 J/K·mol)

[3 marks]

Question 3

a) With the help of the electronic configuration of Mn, classify Mn as paramagnetic or diamagnetic.

[2 mark]

b) Arrange the following ions in order from smallest to largest ionic radii:

Se^{2-}, Sr^{2+}, Y^{3+}, and Br^{-}.

[2 marks]

c) Draw Lewis structures and then use VSEPR theory to predict the geometrical shapes and bond angle of the following species. **Classify** as polar or nonpolar compounds.

(i) NCl_3

(ii) CCl_4

[4 marks]

d) KI has a higher melting point than I_2. Briefly explain why in terms of intermolecular forces.

[2 marks]

Question 4

a) The Henry's law constant for N_2, O_2 and CO_2 in water at 25 ^oC is 6.25 x 10^{-4} M/atm, 1.28 x 10^{-3} M/atm and 3.45 x 10^{-2} M/atm and their partial pressures are 0.78atm, 0.21 atm and 0.041 atm respectively. What is the equilibrium concentration of these gases in water when the gas pressure over the water is 1.00 atm? Which of these gases will have the highest concentration in water at the same temperature and pressure?

[3 marks]

b) What is the boiling point of a solution containing 0.80 g caffeine, $C_8H_{10}N_4O_2$, dissolved in 13.20 g benzene? The boiling point of pure benzene is 80.1 ^oC and the boiling point elevation constant, K_{bp}, is 2.53 $^oC/m$.

[2.5 marks]

c) The osmotic pressure of blood is 775 kPa at 37.0°C. What mass of NaCl is needed to prepare 2.00 L of saline solution for intravenous injection? [Hint: The osmotic pressure of the saline solution must equal the osmotic pressure of blood.]

[2.5 marks]

d) The half-life of vanadium-48 is 16.0 days. If a tank contains 3.32 x 10^{28} molecules of vanadium-48 per litre, how much vanadium-48 will be left after 365 days?

[2 marks]

Question 5

a) Following experimental data were collected for the reaction

$2Na_2SO_3(aq) + NaClO_2(aq) \rightarrow NaCl(aq) + 2NaSO_4(aq)$ at 25°C.

Experiment No.	$[Na_2SO_3]$, in mol L^{-1}	$[NaClO_2]$, in mol L^{-1}	Rate, in mol L^{-1} s^{-1}
1	0.050	0.010	1.2×10^{-5}
2	0.10	0.010	2.3×10^{-5}
3	0.20	0.020	9.5×10^{-5}

Determine the full rate equation, including the value of the rate constant, k and its units.

[3 marks]

b) For the equilibrium: $2COF_2(g) \rightleftharpoons CO_2(g) + CF_4(g)$ [K_{eq} = 2.00, at 750 °C]

In an equilibrium mixture, the concentration of COF_2 is 0.285 M and concentration of CF_4 is 0.123 M.

(i) What is the equilibrium concentration of CO_2 ?

(ii) What is the value of K_p at 750 °C

[3 marks]

c) What is the pH of 0.18 M aqueous formate ion? (K_b of HCO_2^- = 5.6×10^{-11})

[2 marks]

d) Aluminium hydroxide is only slightly soluble in water, having $K_{sp} = 1.8 \times 10^{-5}$ at 25°C. Calculate the solubility of Aluminium hydroxide in water at 25°C in mol/L.

[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, $R = 2.179 \times 10^{-18}$

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

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

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

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

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

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

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

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

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	$r = k[A]^2$	$\frac{1}{[A]_t} = kt + \frac{1}{[A]_o}$

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

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

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

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

Periodic Table of Elements

	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H Hydrogen 1.01	2 2A																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	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	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.