Chemistry SCH4U-C
Practice Test

Time: 2 hours
Total Marks: 103 **Final Test Score: _____ ÷ 103 × 100 = _____%**

Instructions

- There is a label attached to this page. Compare the course code on the label with the course code printed on the Final Test to make sure that they are the same. Tell the Final Test supervisor **immediately** if they are not the same.
- The Final Test pages are numbered 1 through 20. Check to see that all 20 pages are there. Tell the Final Test supervisor **immediately** if there are any pages missing.
- You may use a non-marked dictionary during the Final Test if one is available at the test site. You may not use any other books or notes.
- You will need a pen and a scientific calculator.
- There is a periodic table of the elements included at the beginning to assist you with the chemistry questions.
- You must write your answers in the space provided.
- This test has three parts. A breakdown of the marks and the approximate time needed for each part is given below. Look over the entire test before you begin. Manage your time carefully and leave some time at the end to review your work.

Part	Activity	Marks	Time (minutes)
	Preview		5
A	Structure of Matter and Organic Chemistry	25	30
B	Oxidation Reduction Reactions, Electrochemistry, and Energy	39	40
C	Rates of Reaction and Equilibrium Applications	39	40
	Review		5
Total		**103**	**120**

- At the end of the test, return this test paper and all of your work (including drafts) to the Final Test supervisor.
- Please note that, for security reasons, marked tests are not returned to students.
- Mathematical solutions require a proper problem-solving format. Final answers must include the correct units and the correct number of significant figures.

Formula Sheet and Periodic Table of the Elements

Formula Sheet

You will need a scientific calculator that is able to do exponents, logarithms, square roots, and cube roots.

$$n = \frac{m}{M}$$

$$c = \frac{n}{V}$$

$$q = mc\Delta T$$

$$\Delta H = \Sigma \Delta H_{f(products)} - \Sigma \Delta H_{f(reactants)}$$

$$K_{eq} = \frac{[products]}{[reactants]}$$

$$(\text{for } A_xB_y) \qquad K_{sp} = [A^+]^x[B^-]^y$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$K_b = \frac{[HB^+][OH^-]}{[B]}$$

$$pH = -\log[H_3O^+]$$

Periodic Table

Atomic Number → 6
Symbol → C
Name → Carbon
Average Atomic Mass → 12.011
Common Oxidation States → 4, -4, 2

Period	Group 1 IA	Group 2 IIA	Group 3 IIIB	Group 4 IVB	Group 5 VB	Group 6 VIB	Group 7 VIIB	Group 8	Group 9 VIIIB	Group 10	Group 11 IB	Group 12 IIB	Group 13 IIIA	Group 14 IVA	Group 15 VA	Group 16 VIA	Group 17 VIIA	Group 18 VIIIA
1	1 H Hydrogen 1.00794 (1, -1)																	2 He Helium 4.002602
2	3 Li Lithium 6.941 (1)	4 Be Beryllium 9.012182 (2)											5 B Boron 10.811 (3)	6 C Carbon 12.011 (4, -4, 2)	7 N Nitrogen 14.00674 (3, -3, 5)	8 O Oxygen 15.9994 (-2)	9 F Fluorine 18.9984032 (-1)	10 Ne Neon 20.1797
3	11 Na Sodium 22.989768 (1)	12 Mg Magnesium 24.3050 (2)											13 Al Aluminum 26.981539 (3)	14 Si Silicon 28.0855 (4)	15 P Phosphorus 30.973762 (5, -3, 3)	16 S Sulfur 32.066 (6, -2, 2)	17 Cl Chlorine 35.4527 (-1, 1, 3)	18 Ar Argon 39.948
4	19 K Potassium 39.0983 (1)	20 Ca Calcium 40.078 (2)	21 Sc Scandium 44.955910 (3)	22 Ti Titanium 47.88 (4, 3)	23 V Vanadium 50.9415 (5, 4, 3)	24 Cr Chromium 51.9961 (3, 2, 6)	25 Mn Manganese 54.93805 (2, 3, 4)	26 Fe Iron 55.847 (2, 3)	27 Co Cobalt 58.93320 (2, 3)	28 Ni Nickel 58.6934 (2, 3)	29 Cu Copper 63.546 (2, 1)	30 Zn Zinc 65.39 (2)	31 Ga Gallium 69.723 (3)	32 Ge Germanium 72.61 (4)	33 As Arsenic 74.92159 (3, -3, 5)	34 Se Selenium 78.96 (4, -2, 6)	35 Br Bromine 79.904 (-1, 1, 5)	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.4678 (1)	38 Sr Strontium 87.62 (2)	39 Y Yttrium 88.90585 (3)	40 Zr Zirconium 91.224 (4)	41 Nb Niobium 92.90638 (5, 3)	42 Mo Molybdenum 95.94 (6, 5, 4)	43 Tc Technetium (97.90772) (7)	44 Ru Ruthenium 101.07 (3, 4, 6)	45 Rh Rhodium 102.90550 (3, 2, 4)	46 Pd Palladium 106.42 (2, 4)	47 Ag Silver 107.8682 (1)	48 Cd Cadmium 112.411 (2)	49 In Indium 114.818 (3)	50 Sn Tin 118.710 (4, 2)	51 Sb Antimony 121.757 (3, -3, 5)	52 Te Tellurium 127.60 (4, -2, 6)	53 I Iodine 126.90447 (-1, 1, 5)	54 Xe Xenon 131.29
6	55 Cs Cesium 132.90543 (1)	56 Ba Barium 137.327 (2)	57 La Lanthanum 138.9055 (3)	72 Hf Hafnium 178.49 (4)	73 Ta Tantalum 180.9479 (5)	74 W Tungsten 183.84 (6, 5, 4)	75 Re Rhenium 186.207 (7, -1, 6)	76 Os Osmium 190.23 (4, 2, 3)	77 Ir Iridium 192.22 (4, 2, 3)	78 Pt Platinum 195.08 (4, 2)	79 Au Gold 196.96654 (3, 1)	80 Hg Mercury 200.59 (2, 1)	81 Tl Thallium 204.3833 (1, 3)	82 Pb Lead 207.2 (2, 4)	83 Bi Bismuth 208.98037 (3, 5)	84 Po Polonium (208.9824) (4, 2)	85 At Astatine (209.9871) (-1, 1, 3)	86 Rn Radon (222.01761)
7	87 Fr Francium (223.0197) (1)	88 Ra Radium (226.0254) (2)	89 Ac Actinium (227.0278) (3)	104 Rf Rutherfordium (261.11)	105 Db Dubnium (262.114)	106 Sg Seaborgium (263.118)	107 Bh Bohrium (262.12)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (269)	111 Rg Roentgenium (272)	112 Uub Ununbium (275)	113 Uut Ununtrium (278)	114 Uuq Ununquadium (282)	115 Uup Ununpentium	116 Uuh Ununhexium	117 Uus Ununseptium	118 Uuo Ununoctium

58 Ce Cerium 140.115 (3, 4)	59 Pr Praseodymium 140.90765 (3, 4)	60 Nd Neodymium 144.24 (3)	61 Pm Promethium (144.9127) (3)	62 Sm Samarium 150.36 (3, 2)	63 Eu Europium 151.965 (3, 2)	64 Gd Gadolinium 157.25 (3)	65 Tb Terbium 158.92534 (3, 4)	66 Dy Dysprosium 162.50 (3)	67 Ho Holmium 164.93032 (3)	68 Er Erbium 167.26 (3)	69 Tm Thulium 168.93421 (3, 2)	70 Yb Ytterbium 173.04 (3, 2)	71 Lu Lutetium 174.967 (3)
90 Th Thorium 232.0381 (4)	91 Pa Protactinium 231.03588 (5, 4)	92 U Uranium 238.0289 (6, 5, 4)	93 Np Neptunium (237.0482) (5, 4, 3)	94 Pu Plutonium (244.0642) (4, 3, 5)	95 Am Americium (243.0614) (3, 4, 5)	96 Cm Curium (247.0703) (3)	97 Bk Berkelium (247.0703) (3, 4)	98 Cf Californium (251.0796) (3)	99 Es Einsteinium (252.083)	100 Fm Fermium (257.0951)	101 Md Mendelevium (258.10)	102 No Nobelium (259.1009)	103 Lr Lawrencium (262.111)

Part A: Structure of Matter and Organic Chemistry 25 marks *(approximate time: 30 minutes)*

1. Two of the lines in the hydrogen emission spectrum are coloured violet and blue-green. Violet light is known to have more energy than blue-green light. How did Niels Bohr explain the origin of these two lines? **(4 marks)**

2. Write the electronic configuration for an atom of potassium, which is element 19 on the periodic table. **(2 marks)**

3. **a)** Draw the Lewis structure (that is, the electron dot diagram) and structural formula for the sulfite ion, SO_3^{2-}. **(4 marks)**

b) Predict the shape of the sulfite ion. **(1 mark)**

c) Is the sulfite ion polar or non-polar? Justify your prediction. **(3 marks)**

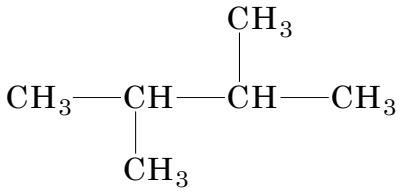
4. Methanol and ethane have nearly the same molar mass. Refer to intermolecular forces to explain why there is such a large difference in their boiling points.

Compound	Formula	Boiling point (°C)
Ethane	C_2H_6	–89
Methanol	CH_3OH	65

(3 marks)

5. Name these compounds. **(4 marks total)**

a)



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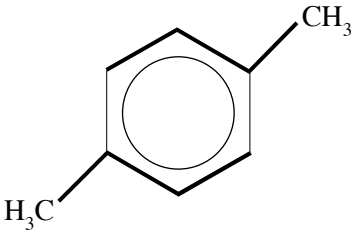
b)



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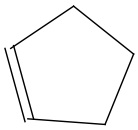
c)



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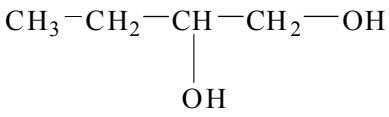
d)



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6. Draw the structural formula for these compounds. **(4 marks total)**

a) 3,4-diethylhexane

b) propene

c) 3,3-dimethylhexane

d) methyl propanoate

Part B: Oxidation Reduction Reactions, Electrochemistry, and Energy 39 marks
(approximate time: 40 minutes)

7. Write a balanced equation for each of the following reactions.

a) The reaction of methanol with ethanoic acid in the presence of a sulfuric acid catalyst. Use structural formulas for all organic compounds in your equation. **(3 marks)**

b) The complete combustion of ethanol. Use molecular formulas for each chemical. **(3 marks)**

8. The following table shows the boiling points of alkanes and the corresponding alkyl chlorides.

Alkane	Boiling point (°C)
CH_4	–164
C_2H_6	–89
C_3H_8	–42

Alkyl chloride	Boiling point (°C)
CH_3Cl	–24
C_2H_5Cl	12
C_3H_7Cl	14

a) What effect does the size of the molecule have on the boiling point for both groups of compounds? **(1 mark)**

b) What effect does the presence of a chlorine atom have on the boiling point of the corresponding alkyl chlorides? **(1 mark)**

c) Identify the type of intermolecular forces that occurs in both groups of compounds. Use the difference in forces to explain the difference in boiling points. **(3 marks)**

9. **a)** Chloroethene is the monomer used to manufacture the polymer called polyvinyl chloride. Distinguish between the terms "monomer" and "polymer." **(2 marks)**

b) Write a chemical equation showing the synthesis of polyvinyl chloride. **(2 marks)**

c) Why is this reaction an example of addition polymerization? **(1 mark)**

10. Use half-reactions to write a balanced chemical equation for the following net ionic equation. Assume that the reaction is occurring in water. Show each step in the process. **(6 marks)**

$Cr_2O_7^{2-} + NO \rightarrow Cr^{3+} + NO_3^-$

11. Consider the following reduction half-cell reactions and potentials:

$Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$ $\quad E° = +0.80\ V$

$Zn^{2+}_{(aq)} + 2e^{-} \rightarrow Zn_{(s)}$ $\quad E° = -0.76\ V$

a) In the galvanic cell that uses these half-cells, predict which reaction will occur at the anode and which will occur at the cathode, and state the type of reaction each will be. **(2 marks)**

b) Use this information to determine the cell potential if this redox reaction were occurring in a galvanic cell. **(1 mark)**

12. These are two half-reactions for a hydrogen fuel cell:

Anode reaction: $2H_2 \rightarrow 4H^{+} + 4e^{-}$

Cathode reaction: $O_2 + 4H^{+} + 4e^{-} \rightarrow 2H_2O$

a) Write the overall cell reaction for the hydrogen fuel cell. **(1 mark)**

b) Refer to your answer in (a) to explain why running a car on hydrogen fuel cells would be better for the environment than running it on gasoline. **(2 marks)**

13. A student heated 100.0 mL of water in an aluminum container using an alcohol burner filled with ethanol (C_2H_5OH). The mass of the aluminum container was 42.5 g. The initial temperature of the water was 17.5°C and the final temperature was 26.3°C. The initial mass of the alcohol burner was 113.45 g and the final mass was 112.97 g. Calculate the molar heat of the combustion of ethanol. The specific heat capacities are c_{Al} = 0.900 J/g°C and c_{H_2O} = 4.18 J/g°C. **(6 marks)**

14. Butane (C_4H_{10}) has a ΔH of –2871 kJ/mol when it undergoes complete combustion into carbon dioxide and liquid water. Given the following ΔH_f values:

Carbon dioxide = –393.5 kJ/mol

Oxygen gas = 0 kJ/mol

Liquid water = –285.8 kJ/mol

a) Write the balanced thermochemical equation for the complete combustion of 1 mol of butane. **(2 marks)**

b) Calculate ΔH_f of butane in kJ/mol. **(3 marks)**

Part C: Rates of Reaction and Equilibrium Applications 39 marks *(approximate time: 40 minutes)*

15. The balanced chemical equation for the reaction between iodine vapour and fluorine gas is:

$3I_{2(g)} + 6F_{2(g)} \rightarrow 2IF_{5(g)} + I_4F_{2(g)}$

A chemist measures the rate at which iodine vapour is consumed to be 4.5×10^{-4} mol/(L•s). At what rate is $F_{2(g)}$ consumed? **(2 marks)**

16. Use the collision theory to explain the following. **(2 marks total)**

a) Chopped vegetables will cook faster than whole vegetables.

b) When a piece of magnesium is held in a flame, it ignites.

17. Use the concentration-rate data presented in the following table to answer the following questions about the hypothetical reaction $2A + 3B \rightarrow 2C$.

[A] in mol/L	[B] in mol/L	Rate in mol/L•s
0.100	0.100	3.0×10^{-4}
0.300	0.100	9.0×10^{-4}
0.300	0.200	3.6×10^{-3}
0.200	0.300	**?**

a) What is the order of reaction, with regard to each reactant? **(2 marks)**

b) Write the rate law equation for this reaction. **(1 mark)**

c) Calculate the rate indicated by the "?" **(2 marks)**

18. The following equilibrium reaction has a K_{eq} value of 2.5×10^{-6}:

$2CO_{2(g)} \rightleftharpoons 2CO_{(g)} + O_{2(g)}$

Calculate the equilibrium concentrations of all gases if 0.800 mol of $CO_{2(g)}$ is initially placed in a 2.00 L reaction container. **(5 marks)**

19. Le Châtelier's principle states that when a system at equilibrium is affected by some kind of stress and loses equilibrium, the system will return to equilibrium by shifting the reaction either to the right or left (forwards or backwards) to minimize the effect of the stress. Use Le Châtelier's principle to describe and explain the shifts caused by the listed stresses placed on the following equilibrium reaction. **(5 marks total)**

$3Cl_{2(g)} + CS_{2(g)} \rightleftharpoons CCl_{4(g)} + S_2Cl_{2(g)}$ $\Delta H = -465$ kJ

a) Adding $CCl_{4(g)}$

b) Adding $Cl_{2(g)}$

c) Adding a catalyst

d) Decreasing the volume

e) Increasing the temperature

20. The K_{sp} for MgF_2 is 6.4×10^{-9}. What mass of MgF_2 will dissolve in 500 mL of distilled water? **(5 marks)**

21. **a)** What is the pH of a strong acid with [HA] = 0.125 mol/L? **(1 mark)**

b) What is the pH of a weak acid with [HA] = 0.125 mol/L and $K_a = 5.4 \times 10^{-7}$? **(4 marks)**

22. During a titration, 28.0 mL of 0.150 mol/L $H_2SO_{4(aq)}$ neutralizes 35.0 mL of $NH_4OH_{(aq)}$. The K_a for H_2SO_4 is very large. The K_b for NH_4OH is 1.8×10^{-5}.

a) Write the balanced equation for the neutralization reaction. **(1 mark)**

b) Calculate the concentration of the $NH_4OH_{(aq)}$. **(2 marks)**

c) From the table below, select an indicator to use in a titration. Explain your selection. **(2 marks)**

Indicator	Range of pH of colour change
Bromocresol purple	5.2 – 6.8
Litmus	6.0 – 8.0
m-cresol purple	7.6 – 9.2

23. A buffer is created by adding 0.35 mol of sodium benzoate to 1.00 L of a 0.40 mol/L benzoic acid solution. The K_a of benzoic acid is 6.3×10^{-5}. What is the pH of the buffer? **(5 marks)**