

CHEMISTRY 1A (ADVANCED) - CHEM1901CHEMISTRY 1A (SPECIAL STUDIES PROGRAM) - CHEM1903FIRST SEMESTER EXAMINATION**CONFIDENTIAL****JUNE 2002****TIME ALLOWED: THREE HOURS**

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		SID NUMBER	
OTHER NAMES		TABLE NUMBER	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 16 pages of examinable material.
- Complete the written section of the examination paper in **INK**.
- Read each question carefully. Report the appropriate answer and show all relevant working in the space provided.
- The total score for this paper is 100. The possible score per page is shown in the adjacent tables.
- Each new short answer question begins with a
 - .
- Electronic calculators, including programmable calculators, may be used. Students are warned, however, that credit may not be given, even for a correct answer, where there is insufficient evidence of the working required to obtain the solution.
- Numerical values required for any question and a Periodic Table may be found on a separate data sheet.
- Pages 10, 15 & 20 are for rough working only.

OFFICIAL USE ONLY**Multiple choice section**

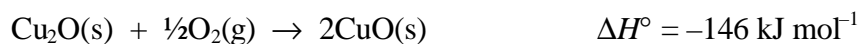
	Marks	
Pages	Max	Gained
2-9	50	

Short answer section

Page	Marks		Marker
	Max	Gained	
11	6		
12	4		
13	7		
14	6		
16	6		
17	8		
18	7		
19	6		
Total	50		

Check Total		
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- Copper(I) is oxidised to copper(II) in the following reaction.



Given that ΔH_f° of $\text{Cu}_2\text{O}(\text{s})$ is $-198.8 \text{ kJ mol}^{-1}$, calculate ΔH_f° of $\text{CuO}(\text{s})$.

Mark
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2

ANSWER:

- Atmospheric greenhouse gases are typically transparent to visible light (i.e. do not absorb in this frequency range) and opaque (i.e. absorb) at infrared frequencies. Briefly explain how these two features result in warming at the Earth's surface.

2

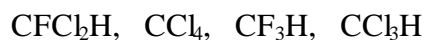
- Explain why electrons in atoms are not simply pulled continuously in towards the positive nucleus.

2

- Explain, in terms of the quantum theory of atomic structure, why the Group 2 metals have significantly larger electron affinities than do the Group 1 metals.

Mark
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2

- Order the following molecules in terms of increasing molecular dipole moment.



smallest dipole

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largest dipole

- Write a balanced nuclear equation for the formation of ${}_{22}^{48}\text{Ti}$ through positron emission.

1

1

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- Complete the following table.

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Species	<u>S</u> Cl ₂	H ₃ <u>O</u> ⁺	<u>S</u> OF ₄
Number of valence electron pairs about the underlined atom not involved in π bonding			
Shape of species			

- In a calorimetry experiment similar to E10, 50.0 mL of 1.00 M HNO₃ was combined with 50.0 mL of 0.540 M NaOH in a calorimeter. The heat capacity of the calorimeter is 80.0 J K⁻¹ and the heat capacity of the final solution is 426 J K⁻¹. The temperature was found to increase by 2.98 °C. Determine the molar heat of reaction for the process H⁺(aq) + OH⁻(aq) → H₂O(l).

4

ANSWER:

The average bond enthalpy of the O–H bond is 463 kJ mol⁻¹. Explain briefly why the heat of neutralisation calculated in the first part of this question differs significantly from this value.

- A rock sample is found to contain 2.100×10^{-15} mol of ^{232}Th , a nuclide with a half life of 1.4×10^{10} years. Analysis of the sample reveals that 9.5×10^6 ^{232}Th nuclei have undergone decay. Using this information, estimate the age of the rock.

**Mark
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ANSWER:

- ClO_3 is a highly reactive molecule. With reference to the Lewis structure of the molecule, explain why this is so.

2

- Explain briefly how electron pairing arises in the quantum theory of atomic structure.

2

- In the equation, $(P + n^2a/V^2)(V - nb) = nRT$, the parameters "a" and "b" are used to correct the Ideal Gas Equation, $PV = nRT$, for non-ideal behaviour. Briefly explain what aspect of non-ideal behaviour each of these parameters corrects.

**Mark
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- One way of separating oxygen isotopes is by gaseous effusion of carbon monoxide. Calculate the relative rates of effusion of $^{12}\text{C}^{16}\text{O}$ and $^{12}\text{C}^{18}\text{O}$.

4

How many effusion processes would be needed to give a 23% increase in the $^{12}\text{C}^{16}\text{O} / ^{12}\text{C}^{18}\text{O}$ ratio?

- The decomposition of ozone to oxygen gas, $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$, is found to have the following rate law:

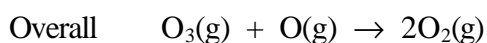
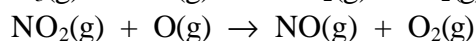
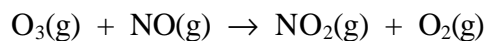
$$\text{Rate} = k[\text{O}_3]$$

Provide a mechanism for this reaction that is consistent with this rate law.

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At 25 °C and an initial ozone concentration of 0.0100 M, the rate of formation of O_2 is $5.94 \times 10^{-6} \text{ mol L}^{-1} \text{ s}^{-1}$. How long would it take for the $[\text{O}_3]$ to drop to one tenth of its initial value at this temperature?

One important mechanism for the destruction of ozone in the upper atmosphere is



Name the species that are the catalyst and the intermediate in this two-step reaction.

E_a for the catalysed reaction is 11.9 kJ mol^{-1} whereas E_a for the uncatalysed reaction is 14.0 kJ mol^{-1} . At $-45 \text{ }^\circ\text{C}$, the temperature of the ozone layer, what is the ratio of the rate constant for the catalysed reaction to that of the uncatalysed reaction? Assume that the frequency factor, A , is the same for each reaction.

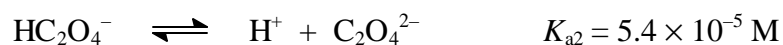
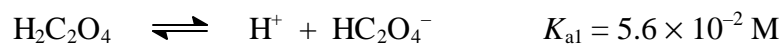
- A 0.25 M water solution of trimethylamine, $(\text{CH}_3)_3\text{N}$, has a pOH of 2.40. Find the K_b for trimethylamine and the $\text{p}K_a$ for the trimethylammonium ion, $(\text{CH}_3)_3\text{NH}^+$.

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$K_b =$

$\text{p}K_a =$

- Oxalic acid is a diprotic acid:



Calculate the pH of a buffer solution made by adding 3.0 mol of $\text{H}_2\text{C}_2\text{O}_4$ and 1.0 mol of $\text{Na}_2\text{C}_2\text{O}_4$.

2

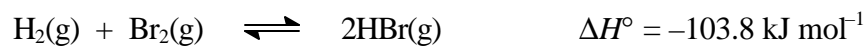
pH =

- Calculate the pH of 1.0×10^{-7} M hydrochloric acid.

2

pH =

- Consider the following reaction.



In a particular experiment, equimolar amounts of $\text{H}_2(\text{g})$ and $\text{Br}_2(\text{g})$ were mixed in a 1.00 L flask at 25 °C to give a total pressure of 1.00 atm. After the system had reached equilibrium, 1.10×10^{13} H_2 molecules remained in the flask. Calculate the values of K , ΔG° and ΔS° for this reaction at 25 °C.

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$K =$

$\Delta G^\circ =$

$\Delta S^\circ =$

Using Le Châtelier's principle, predict the direction in which the equilibrium will shift if the temperature is increased. Explain your answer.

The University of Sydney

CHEMISTRY 1A (ADVANCED) - CHEM1901CHEMISTRY 1A (SPECIAL STUDIES PROGRAM) - CHEM1903

FIRST SEMESTER EXAMINATION

JUNE 2002

Numerical Data*Physical constants*

$$\text{Planck constant} = h = 6.626 \times 10^{-34} \text{ J s}$$

$$\text{Speed of light in vacuum} = c_0 = 2.998 \times 10^8 \text{ ms}^{-1}$$

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

$$\begin{aligned} \text{Ideal gas constant} = R &= 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \\ &= 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} \end{aligned}$$

Conversion factors

$$1 \text{ nm} = 10^{-9} \text{ m}$$

$$1 \text{ kJ} = 10^3 \text{ J}$$

$$1 \text{ kPa} = 10^3 \text{ Pa}$$

$$1 \text{ L} = 10^{-3} \text{ m}^3$$

$$1 \text{ atm} = 101.3 \text{ kPa}$$

Solution to the quadratic equation

$$\text{If } ax^2 + bx + c = 0 \quad \text{then } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

**A periodic table is printed on the other side of this data sheet.
Atomic weights are included in the periodic table.**

PERIODIC TABLE OF THE ELEMENTS

June 2002

CHEM1901/CHEM1903

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 HYDROGEN H 1.008																	2 HELIUM He 4.003
3 LITHIUM Li 6.941	4 BERYLLIUM Be 9.012											5 BORON B 10.81	6 CARBON C 12.01	7 NITROGEN N 14.01	8 OXYGEN O 16.00	9 FLUORINE F 19.00	10 NEON Ne 20.18
11 SODIUM Na 22.99	12 MAGNESIUM Mg 24.31											13 ALUMINIUM Al 26.98	14 SILICON Si 28.09	15 PHOSPHORUS P 30.97	16 SULFUR S 32.07	17 CHLORINE Cl 35.45	18 ARGON Ar 39.95
19 POTASSIUM K 39.10	20 CALCIUM Ca 40.08	21 SCANDIUM Sc 44.96	22 TITANIUM Ti 47.88	23 VANADIUM V 50.94	24 CHROMIUM Cr 52.00	25 MANGANESE Mn 54.94	26 IRON Fe 55.85	27 COBALT Co 58.93	28 NICKEL Ni 58.69	29 COPPER Cu 63.55	30 ZINC Zn 65.39	31 GALLIUM Ga 69.72	32 GERMANIUM Ge 72.59	33 ARSENIC As 74.92	34 SELENIUM Se 78.96	35 BROMINE Br 79.90	36 KRYPTON Kr 83.80
37 RUBIDIUM Rb 85.47	38 STRONTIUM Sr 87.62	39 YTRIUM Y 88.91	40 ZIRCONIUM Zr 91.22	41 NIOBIUM Nb 92.91	42 MOLYBDENUM Mo 95.94	43 TECHNETIUM Tc [98.91]	44 RUTHENIUM Ru 101.07	45 RHODIUM Rh 102.91	46 PALLADIUM Pd 106.4	47 SILVER Ag 107.87	48 CADMIUM Cd 112.40	49 INDIUM In 114.82	50 TIN Sn 118.69	51 ANTIMONY Sb 121.75	52 TELLURIUM Te 127.60	53 IODINE I 126.90	54 XENON Xe 131.30
55 CAESIUM Cs 132.91	56 BARIUM Ba 137.34	57-71	72 HAFNIUM Hf 178.49	73 TANTALUM Ta 180.95	74 TUNGSTEN W 183.85	75 RHENIUM Re 186.2	76 OSMIUM Os 190.2	77 IRIDIUM Ir 192.22	78 PLATINUM Pt 195.09	79 GOLD Au 196.97	80 MERCURY Hg 200.59	81 THALLIUM Tl 204.37	82 LEAD Pb 207.2	83 BISMUTH Bi 208.98	84 POLONIUM Po [210.0]	85 ASTATINE At [210.0]	86 RADON Rn [222.0]
87 FRANCIUM Fr [223.0]	88 RADIUM Ra [226.0]	89-103	104 RUTHERFORDIUM Rf [261]	105 DUBNIUM Db [262]	106 SEABORGIUM Sg [266]	107 BOHRIUM Bh [262]	108 HASSIUM Hs [265]	109 MEITNERIUM Mt [266]									

LANTHANIDE
S

57 LANTHANUM La 138.91	58 CERIUM Ce 140.12	59 PRASEODYMIUM Pr 140.91	60 NEODYMIUM Nd 144.24	61 PROMETHIUM Pm [144.9]	62 SAMARIUM Sm 150.4	63 EUROPIUM Eu 151.96	64 GADOLINIUM Gd 157.25	65 TERBIUM Tb 158.93	66 DYSPROSIUM Dy 162.50	67 HOLMIUM Ho 164.93	68 ERBIUM Er 167.26	69 THULIUM Tm 168.93	70 YTTERBIUM Yb 173.04	71 LUTETIUM Lu 174.97
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22/08(b)

ACTINIDES

89 ACTINIUM Ac [227.0]	90 THORIUM Th 232.04	91 PROTACTINIUM Pa [231.0]	92 URANIUM U 238.03	93 NEPTUNIUM Np [237.0]	94 PLUTONIUM Pu [239.1]	95 AMERICIUM Am [243.1]	96 CURIUM Cm [247.1]	97 BERKELLIUM Bk [247.1]	98 CALIFORNIUM Cf [252.1]	99 EINSTEINIUM Es [252.1]	100 FERMIUM Fm [257.1]	101 MENDELEVIUM Md [256.1]	102 NOBELIUM No [259.1]	103 LAWRENCIUM Lr [260.1]
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