

Topics in the June 2010 Exam Paper for CHEM1001

Click on the links for resources on each topic.

2010-J-2:

- [Molecules and Ions](#)
- [Stoichiometry](#)

2010-J-3:

- [Lewis Model of Bonding](#)
- [VSEPR](#)

2010-J-4:

- [The Periodic Table](#)
- [Atomic Energy Levels](#)

2010-J-5:

- [Stoichiometry](#)

2010-J-6:

- [Gas Laws](#)

2010-J-7:

- [Stoichiometry](#)
- [Gas Laws](#)

2010-J-8:

- [Chemical Equilibrium](#)

2010-J-9:

- [Thermochemistry](#)
- [First Law of Thermodynamics](#)

2010-J-10:

- [Chemical Equilibrium](#)
- [Equilibrium and Thermochemistry in Industrial Processes](#)

2010-J-11:

- [Electrochemistry](#)
- [Electrolytic Cells](#)

2010-J-12:

- [Electrochemistry](#)
- [Types of Intermolecular Forces](#)

2010-J-13:

- [Batteries and Corrosion](#)

2201(a)

THE UNIVERSITY OF SYDNEY
FUNDAMENTALS OF CHEMISTRY 1A - CHEM1001
FIRST SEMESTER EXAMINATION

CONFIDENTIAL**JUNE 2010****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 22 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 ●.
- Only non-programmable, University-approved calculators may be used.
- Students are warned 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, standard electrode reduction potentials, a Periodic Table and some useful formulas may be found on the separate data sheets.
- Page 24 is for rough working only.

OFFICIAL USE ONLY**Multiple choice section**

	Marks	
Pages	Max	Gained
2-11	34	

Short answer section

Page	Marks		Marker
	Max	Gained	
12	4		
13	9		
14	7		
15	4		
16	4		
17	8		
18	3		
19	6		
20	6		
21	5		
22	6		
23	4		
Total	66		
Check Total			

- Complete the following table.

Name	Formula
	NH ₃
phosphorus trichloride	
	KHCO ₃
calcium phosphate	

- Calculate the number of aluminium atoms in a block of pure aluminium that measures 2.0 cm × 2.0 cm × 3.0 cm. The density of aluminium is 2.7 g cm⁻³.

Marks**2****2**

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- Complete the following table.

Marks
6

Molecule	NH ₃	SF ₄	CO ₂
Number of bonding electron pairs			
Number of non-bonding electron pairs on central atom			
Lewis structure			
Molecular shape			

- What is resonance? Illustrate your answer by using the nitrate ion, NO₃⁻, as an example.

3

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- The element titanium is used as a structural material for bone in joint replacement surgery. Discuss the properties of titanium that make it suitable for this application.

Marks
3

- Gaseous lithium atoms absorb light with a wavelength of 323 nm. The resulting excited lithium atoms lose some energy through collisions with other atoms. One of the emission lines has an energy of 2.44×10^{-19} J.

4

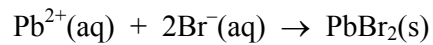
Calculate the energy of the light used for the excitation.

Answer:

Calculate the wavelength of the light emitted.

Answer:

- Lead ions react with bromide ions according to the following equation.



If 0.040 M lead(II) nitrate solution (100.0 mL) is added to 0.020 M potassium bromide solution (300.0 mL), what amount (in mol) of lead(II) bromide precipitates?

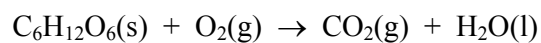
Marks**4**

Answer:

What is the final concentration of $\text{NO}_3^{-}(\text{aq})$ ions remaining in solution after the reaction?

Answer:

- Respiration involves the oxidation of glucose to produce carbon dioxide, water and energy:



Balance this equation.

Marks
4

What volume of $\text{CO}_2(\text{g})$ is produced from the oxidation of 10.0 g of glucose under body conditions ($37\text{ }^\circ\text{C}$, $1.00 \times 10^5\text{ Pa}$)?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- An unknown liquid contains H: 5.90 % and O: 94.1 % by mass and has a molar mass of 33.9 g mol^{-1} . What is its molecular formula?

Marks
2

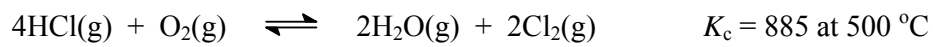
Answer:

- A 2.4 g sample of zinc was dropped into 0.250 L of 5.0 M HCl in a 5.00 L container at $25 \text{ }^\circ\text{C}$ with an initial pressure of 1.0 atm and then the vessel sealed. Calculate the final pressure inside the container.
Hint: The volume occupied by the HCl is significant.

6

Answer:

- Consider the following equilibrium reaction.



If 0.030 mol HCl, 0.020 mol O₂, 0.090 mol H₂O and 0.085 mol Cl₂ are mixed in a 1.0 L container at 500 °C, in what direction will the reaction proceed?

Marks
3

Answer:

What is the value of K_p for the reaction at 500 °C?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- How much energy is needed to convert 15 g of ice at 0.0 °C to water at 60.0 °C? The molar heat of fusion of water is 6.009 kJ mol⁻¹ and the specific heat capacity of water is 4.18 J g⁻¹ K⁻¹.

Marks
3

Answer:

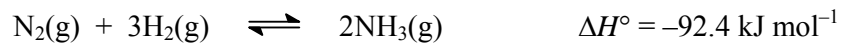
- Calculate the standard enthalpy change for the combustion of 1.00 mol of propane gas, C₃H₈(g), to CO₂(g) and H₂O(l).

3

compound	C ₃ H ₈ (g)	CO ₂ (g)	H ₂ O(l)
$\Delta_f H^\circ / \text{kJ mol}^{-1}$	-105	-394	-286

Answer:

- Ammonia can be produced according to the following equation.



$K_c = 1.5 \times 10^{-5}$ at 500 K. What is the concentration of ammonia at equilibrium if 0.5 mol of $\text{N}_2(\text{g})$ and 1.5 mol of $\text{H}_2(\text{g})$ are placed in an empty 2.0 L flask and allowed to come to equilibrium at 500 K?

Marks
6

Answer:

An additional 0.5 mol of nitrogen is added to the flask described above and equilibrium re-established. Will the equilibrium constant have increased, decreased or remained the same? Justify your answer.

What now is the equilibrium concentration of ammonia?

Answer:

- Write the two half equations and hence balance the equation for the following redox reaction:

**Marks**
3

Working

Balanced equation:

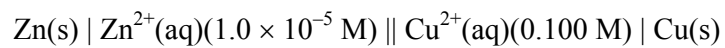
Which species is oxidised?

- In the electro-refining of Pt, what mass of Pt is deposited from a solution of PtCl_6^{2-} in 1.00 hour, by a current of 1.62 A?

2

Answer:

- What is the voltage of the following electrochemical cell at 25 °C?



Marks
3

Answer:

- Rationalise the order of the boiling points of the following liquids in terms of their intermolecular forces.

liquid	F ₂	HCl	HBr	Cl ₂	HF	Br ₂
b.p. (° C)	-188	-85	-67	-34	20	59

3

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- The aluminium-air battery, in which aluminium metal is oxidised to Al^{3+} and O_2 is reduced to OH^- , is being considered as a power source in cars. Briefly compare the relative merits of such a battery with those of a fuel cell for such applications.

Marks
4

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A**DATA SHEET***Physical constants*Avogadro constant, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$ Faraday constant, $F = 96485 \text{ C mol}^{-1}$ Planck constant, $h = 6.626 \times 10^{-34} \text{ J s}$ Speed of light in vacuum, $c = 2.998 \times 10^8 \text{ m s}^{-1}$ Rydberg constant, $E_R = 2.18 \times 10^{-18} \text{ J}$ Boltzmann constant, $k_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$ Permittivity of a vacuum, $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ J}^{-1} \text{ m}^{-1}$ Gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
 $= 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$ Charge of electron, $e = 1.602 \times 10^{-19} \text{ C}$ Mass of electron, $m_e = 9.1094 \times 10^{-31} \text{ kg}$ Mass of proton, $m_p = 1.6726 \times 10^{-27} \text{ kg}$ Mass of neutron, $m_n = 1.6749 \times 10^{-27} \text{ kg}$ *Properties of matter*

Volume of 1 mole of ideal gas at 1 atm and 25 °C = 24.5 L

Volume of 1 mole of ideal gas at 1 atm and 0 °C = 22.4 L

Density of water at 298 K = 0.997 g cm⁻³*Conversion factors*

1 atm = 760 mmHg = 101.3 kPa

1 Ci = 3.70×10^{10} Bq

0 °C = 273 K

1 Hz = 1 s⁻¹1 L = 10⁻³ m³1 tonne = 10³ kg1 Å = 10⁻¹⁰ m1 W = 1 J s⁻¹1 eV = 1.602 × 10⁻¹⁹ J*Decimal fractions*

Fraction	Prefix	Symbol
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p

Decimal multiples

Multiple	Prefix	Symbol
10 ³	kilo	k
10 ⁶	mega	M
10 ⁹	giga	G

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A*Standard Reduction Potentials, E°*

Reaction	E° / V
$\text{Co}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Co}^{2+}(\text{aq})$	+1.82
$\text{Ce}^{4+}(\text{aq}) + \text{e}^- \rightarrow \text{Ce}^{3+}(\text{aq})$	+1.72
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}$	+1.51
$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Au}(\text{s})$	+1.50
$\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2 + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$	+1.23
$\text{Pt}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pt}(\text{s})$	+1.18
$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{Mn}^{3+} + 2\text{H}_2\text{O}$	+0.96
$\text{NO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + 3\text{e}^- \rightarrow \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0.96
$\text{Pd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pd}(\text{s})$	+0.92
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.53
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.15
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0 (by definition)
$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.04
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.24
$\text{Cd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cd}(\text{s})$	-0.40
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Cr}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.89
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.68
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.36
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.87
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.04

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A

Useful formulas

<p>Quantum Chemistry</p> $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $E = -Z^2 E_R(1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$ $T\lambda = 2.898 \times 10^6 \text{ K nm}$	<p>Electrochemistry</p> $\Delta G^\circ = -nFE^\circ$ <p>Moles of $e^- = It/F$</p> $E = E^\circ - (RT/nF) \times 2.303 \log Q$ $= E^\circ - (RT/nF) \times \ln Q$ $E^\circ = (RT/nF) \times 2.303 \log K$ $= (RT/nF) \times \ln K$ $E = E^\circ - \frac{0.0592}{n} \log Q \text{ (at 25 }^\circ\text{C)}$
<p>Acids and Bases</p> $pK_w = \text{pH} + \text{pOH} = 14.00$ $pK_w = \text{pK}_a + \text{pK}_b = 14.00$ $\text{pH} = \text{pK}_a + \log \{ [A^-] / [HA] \}$	<p>Gas Laws</p> $PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$ $E_k = \frac{1}{2}mv^2$
<p>Radioactivity</p> $t_{1/2} = \ln 2 / \lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ $^{14}\text{C age} = 8033 \ln(A_0/A_t) \text{ years}$	<p>Kinetics</p> $t_{1/2} = \ln 2 / k$ $k = Ae^{-E_a/RT}$ $\ln[A] = \ln[A]_0 - kt$ $\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$
<p>Colligative Properties & Solutions</p> $\Pi = cRT$ $P_{\text{solution}} = X_{\text{solvent}} \times P^\circ_{\text{solvent}}$ $c = kp$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$	<p>Thermodynamics & Equilibrium</p> $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G = \Delta G^\circ + RT \ln Q$ $\Delta G^\circ = -RT \ln K$ $\Delta_{\text{univ}} S^\circ = R \ln K$ $K_p = K_c (RT)^{\Delta n}$
<p>Miscellaneous</p> $A = -\log \frac{I}{I_0}$ $A = \epsilon cl$ $E = -A \frac{e^2}{4\pi\epsilon_0 r} N_A$	<p>Mathematics</p> <p>If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</p> $\ln x = 2.303 \log x$ <p>Area of circle = πr^2</p> <p>Surface area of sphere = $4\pi r^2$</p>

PERIODIC TABLE OF THE ELEMENTS

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 BOHRNIUM Bh [262]	108 HASSIUM Hs [265]	109 MEITNERIUM Mt [266]	110 DARMSTADIUM Ds [271]	111 ROENTGENIUM Rg [272]	112 COPERNICIUM Cn [283]						

LANTHANOID 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 YTERBIUM Yb 173.04	71 LUTETIUM Lu 174.97
ACTINOIDS	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 BERKELIUM 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]