

Topics in the June 2007 Exam Paper for CHEM1001

Click on the links for resources on each topic.

2007-J-2:

- [Elements and Atoms](#)
- [Chemical Equations](#)
- [Stoichiometry](#)

2007-J-3:

- [Lewis Model of Bonding](#)
- [VSEPR](#)
- [Elements and Atoms](#)

2007-J-4:

- [Stoichiometry](#)
- [Chemical Equations](#)

2007-J-5:

- [Chemical Equations](#)
- [Stoichiometry](#)

2007-J-6:

- [Thermochemistry](#)
- [Chemical Equilibrium](#)

2007-J-7:

- [Introduction to Electrochemistry](#)
- [Electrochemistry](#)
- [First Law of Thermodynamics](#)

2007-J-8:

- [Electrolytic Cells](#)
- [Introduction to Electrochemistry](#)
- [Electrochemistry](#)
- [Batteries and Corrosion](#)

2007-J-9:

- [Chemical Equilibrium](#)

2007-J-10:

- [Gas Laws](#)

FUNDAMENTALS OF CHEMISTRY 1A - CHEM1001**FIRST SEMESTER EXAMINATION****CONFIDENTIAL****JUNE 2007****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 20 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, standard electrode reduction potentials, a Periodic Table and some useful formulas may be found on the separate data sheet.
- Pages 17, 21 and 24 are for rough working only.

OFFICIAL USE ONLY**Multiple choice section**

Pages	Marks	
	Max	Gained
2-12	40	

Short answer section

Page	Marks		Marker
	Max	Gained	
13	9		
14	11		
15	8		
16	7		
18	5		
19	4		
20	7		
22	4		
23	5		
Total	60		
Check Total			

Marks**4**

- Write balanced equations for the following nuclear reactions.

Naturally occurring thorium 232 undergoes alpha decay.

A nuclide undergoes beta decay and produces caesium 133.

- A cook uses a microwave oven to heat up a meal. The wavelength of the radiation is 0.012 m. Calculate the frequency and energy of a photon of this radiation.

2

Frequency:

Energy:

- What mass of calcium chloride is required to make 250 mL of a 0.1 M solution?

3

Answer:

What amount of chloride ions (in mol) is present in 30.0 mL of this solution?

Answer:

- Complete the following table.

Marks
9

Molecular formula	SF ₆		NH ₃
Name		chlorine trifluoride	
Lewis structure			
Number of bonding electron pairs on central atom			
Number of non-bonding electron pairs on central atom			
Molecular shape			

- Silicon is essential to the computer industry as a major component of chips. It has three naturally occurring isotopes, the relative abundance of each being given below. Calculate the atomic mass of silicon.

2

Isotope	Mass of isotope (a.m.u.)	Relative abundance
²⁸ Si	27.9769	92.23%
²⁹ Si	28.9765	4.67%
³⁰ Si	29.9738	3.10%

Answer:

Marks
4

- The complete combustion of butane, C_4H_{10} , in air gives water and carbon dioxide as the products. Write a balanced equation for this reaction.

What mass of oxygen is required for the complete combustion of 454 g of butane and what masses of carbon dioxide and water are produced?

- During physical activity, lactic acid forms in the muscle tissue and is responsible for muscle soreness. Elemental analysis shows that it contains by mass 40.0% C, 6.71% H and 53.3% O. Determine the empirical formula of lactic acid.

4

Answer:

Given that lactic acid has a molar mass of 90.08 g mol^{-1} , determine its molecular formula.

Answer:

Marks
4

- If 50 mL of a 0.10 M solution of AgNO_3 is mixed with 50 mL of a 0.40 M solution of Na_2CO_3 , what mass of Ag_2CO_3 will precipitate from the reaction?

Answer:

What is the final concentration of CO_3^{2-} ions in the solution after the above reaction?

Answer:

- Give balanced ionic equations for the reactions that occur in each of the following cases.

3

Sodium metal is added to excess water.

Solutions of cobalt(II) nitrate and sodium phosphate are mixed.

Solid calcium carbonate is dissolved in dilute nitric acid.

Marks
3

- A 60.0 g piece of Ag metal is heated to 90.0 °C and dropped into 120.0 g of water at 25.0 °C in a well insulated container. The final temperature of the Ag-H₂O mixture is 26.7 °C. Calculate the specific heat of silver.
Data: The specific heat of water is 4.18 J g⁻¹ K⁻¹.

Answer:

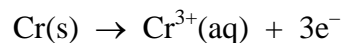
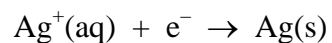
- Determine K_c for the reaction $\frac{1}{2}\text{O}_2(\text{g}) + \text{Na}_2\text{O}(\text{s}) \rightleftharpoons \text{Na}_2\text{O}_2(\text{s})$ at 25 °C.

2Data: $\text{Na}_2\text{O}(\text{s}) \rightleftharpoons 2\text{Na}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \quad K_c = 2 \times 10^{-25}$ at 25 °C. $\text{Na}_2\text{O}_2(\text{s}) \rightleftharpoons 2\text{Na}(\text{s}) + \text{O}_2(\text{g}) \quad K_c = 5 \times 10^{-29}$ at 25 °C.

Answer:

Marks
2

- Consider a cell composed of the following half-reactions.

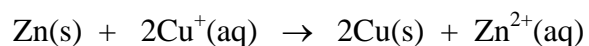


What is the balanced equation for the spontaneous reaction?

What is the value of E° for the cell? Relevant standard reduction potentials are on the data sheet.

Answer:

- Calculate the standard heat of reaction for the following reaction.



Data: $\Delta H_f^\circ = +51.9 \text{ kJ mol}^{-1}$ for $\text{Cu}^+(\text{aq})$

$\Delta H_f^\circ = -152.4 \text{ kJ mol}^{-1}$ for $\text{Zn}^{2+}(\text{aq})$

Answer:

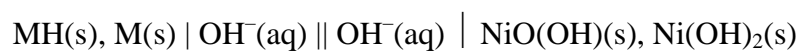
2

Marks
4

- An electrolytic cell contains a solution of MCl_3 . A total charge of 3600 C is passed through the cell, depositing 0.65 g of the metal, M, at the cathode. What is the identity of the metal, M?

Answer:

- A metal-metal hydride battery has the following shorthand notation:



Which component of the battery is the cathode?

Give the balanced half equation of the reaction that takes place at the cathode.

Why is it important that all redox active species are solids in this reaction?

- $K_p = 7.0$ for the reaction $\text{Br}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{BrCl}(\text{g})$ at 400 K.
Suppose a 1.0 L flask is filled with 0.30 atm $\text{Br}_2(\text{g})$ and 0.30 atm $\text{Cl}_2(\text{g})$ at 400 K.
Find the pressures of all three gases at equilibrium.

Marks
4

$p(\text{Br}_2)$:	$p(\text{Cl}_2)$:	$p(\text{BrCl})$:
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THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
2

- The *Voyager I* spacecraft determined that the atmospheric pressure at the surface of Saturn's moon, Titan, is 1.6 times that of earth and that the atmosphere contains 6.0 mol % methane, CH₄. What is the partial pressure of methane on Titan in mmHg?

Answer:

3

- Many gases are available for use in compressed gas cylinders, in which they are stored at high pressures. Calculate the mass of O₂ that can be stored at 20 °C and 170 atm pressure in a cylinder with a volume of 60.0 L.

Answer:

What volume would this mass of oxygen occupy at 1.00 atm pressure and 20 °C?

Answer:

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 = $3.70 \times 10^{10} \text{ Bq}$

0 °C = 273 K

1 Hz = 1 s^{-1} 1 L = 10^{-3} m^3 1 tonne = 10^3 kg 1 Å = 10^{-10} m 1 W = 1 J s^{-1} 1 eV = $1.602 \times 10^{-19} \text{ J}$ *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
$\text{Pd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pd}(\text{s})$	+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> $E = h\nu = hc/\lambda$ $\lambda = h/m\nu$ $4.5k_B T = hc/\lambda$ $E = -Z^2 E_R (1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$	<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> $pK_w = \text{pH} + \text{pOH} = 14.00$ $pK_w = \text{p}K_a + \text{p}K_b = 14.00$ $\text{pH} = \text{p}K_a + \log \{ [A^-] / [HA] \}$	<p>Gas Laws</p> $PV = nRT$ $(P + n^2 a/V^2)(V - nb) = nRT$
<p>Colligative properties</p> $\pi = cRT$ $P_{\text{solution}} = X_{\text{solvent}} \times P^\circ_{\text{solvent}}$ $p = kc$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$	<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>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>Thermodynamics & Equilibrium</p> $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G = \Delta G^\circ + RT \ln Q$ $\Delta G^\circ = -RT \ln K$ $K_p = K_c (RT)^{\Delta n}$
<p>Miscellaneous</p> $A = -\log_{10} \frac{I}{I_0}$ $A = \epsilon cl$ $E = -A \frac{e^2}{4\pi\epsilon_0 r} N_A$	<p>Mathematics</p> <p>If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</p> $\ln x = 2.303 \log x$

PERIODIC TABLE OF THE ELEMENTS

June 2007

CHEM1001 – FUNDAMENTALS OF CHEMISTRY 1A

22/01(b)

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 NOBIUM 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]	110 DARMSTADTIUM Ds [271]	111 ROENTGENIUM Rg [272]							

LANTHANIDES	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
ACTINIDES	89 ACTINIUM Ac [227.0]	90 THORIUM Th 232.04	91 PROFACINIUM 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]