

Topics in the June 2006 Exam Paper for CHEM1001

Click on the links for resources on each topic.

2006-J-2:

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

2006-J-3:

- [Molecules and Ions](#)
- [Elements and Atoms](#)

2006-J-4:

- [Stoichiometry](#)

2006-J-5:

- [Stoichiometry](#)

2006-J-6:

- [Stoichiometry](#)

2006-J-7:

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

2006-J-8:

- [Introduction to Electrochemistry](#)
- [Electrochemistry](#)

2006-J-9:

- [Thermochemistry](#)
- [First Law of Thermodynamics](#)
- [Chemical Equations](#)
- [Stoichiometry](#)

2006-J-10:

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

2006-J-11:

- [Gas Laws](#)

FUNDAMENTALS OF CHEMISTRY 1A - CHEM1001FIRST SEMESTER EXAMINATION**CONFIDENTIAL**

JUNE 2006

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 21 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 18 and 24 are for rough working only.

OFFICIAL USE ONLY~~Multiple choice section~~

		Marks	
Pages	Max	Gained	
2-12	42		

Short answer section

Page	Marks		Marker
	Max	Gained	
13	7		
14	8		
15	7		
16	3		
17	6		
19	7		
20	4		
21	4		
22	8		
23	4		
Total	58		
Check Total			

Marks
2

- Balance the following nuclear reactions by identifying the missing nuclear particle.

**2**

- A nugget contains 2.6×10^{24} atoms of gold. What amount of gold (in mol) is in this nugget and what is its mass (in kg)?

Amount:

Mass:

1

- What element has the ground state electronic arrangement of $1s^2 2s^2 2p^6 3s^2 3p^3$?

2

- A mobile phone sends signals at about 850 MHz ($1 \text{ MHz} = 1 \times 10^6 \text{ Hz}$). What is the wavelength of this radiation?

Wavelength =

- Account for why solid metals can conduct an electric current, but solid ionic compounds cannot.

Marks
3

- Complete the entries in the following table.

3

Element name	Symbol	Mass number	Atomic number	Number of electrons	Number of neutrons	${}^m_z\text{X}$
lithium		7	3			
	Cu			29		${}^{64}_{29}\text{Cu}$
aluminium			13		14	

- Give the formula and name of the binary compound formed from the following elements.

2

	Formula	Name
lithium and oxygen		
calcium and hydrogen		

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks**7**

- The complete combustion of propane, C_3H_8 , in air gives water and carbon dioxide as the products? Write a balanced equation for this reaction.

--

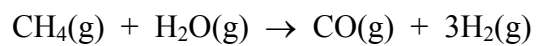
What mass of oxygen is required for the complete combustion of 454 g of propane and what masses of CO_2 and H_2O are produced?

--

Explain the “law of conservation of mass”. Show whether or not the above combustion conforms to this law.

--

- The reaction of methane and water is one way to prepare hydrogen for use as a fuel.



Which compound is the limiting reactant if you begin with 995 g of methane and 2510 g of water?

Marks
3

Answer:

What mass of the excess reactant remains when the reaction is completed?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
4

- An unknown compound contains carbon and hydrogen only. If 0.0956 g of the compound is burned in oxygen, 0.300 g of CO₂ and 0.123 g of H₂O are isolated. What is the unknown compound's empirical formula?

Answer:

If its molar mass is found to be 70.1 g mol⁻¹, what is its molecular formula?

Answer:

1

- What amount (in mol) of chloride ion is contained in 100 mL of 0.25 M magnesium chloride solution?

Answer:

1

- If 25.0 mL of 1.50 M hydrochloric acid is diluted to 500 mL, what is the molar concentration of the diluted acid?

Answer:

Marks
3

- A 1.00 g sample of ammonium nitrate, NH_4NO_3 , is decomposed in a bomb calorimeter causing the temperature of the calorimeter to increase by 6.12 K. The heat capacity of the system is $1.23 \text{ kJ } ^\circ\text{C}^{-1}$.

Describe this process as either endothermic or exothermic.

What is the molar heat of decomposition for ammonium nitrate?

Answer:

4

- Heating SbCl_5 causes it to decompose according to the following equation.

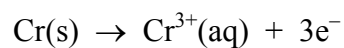
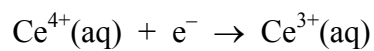


A sample of 0.50 mol of SbCl_5 is placed in a 1.0 L flask and heated to 450°C . When the system reaches equilibrium there is 0.10 mol of Cl_2 present. Calculate the value of the equilibrium constant, K_c , at 450°C .

Answer:

Marks
3

- 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.

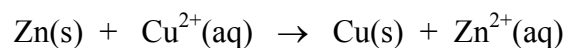
Answer:

- What does the superscript “o” mean in the symbol ΔH_f° ?

1

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

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



Data: $\Delta H_f^\circ = +64.4 \text{ kJ mol}^{-1}$ for $\text{Cu}^{2+}(\text{aq})$

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

Marks**2**

Answer:

- Write a balanced **ionic** equation for the reaction of solid sodium hydrogencarbonate, NaHCO_3 , and dilute sulfuric acid, H_2SO_4 .

2

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- Calculate the mass of silver nitrate, AgNO_3 , required to make 500 mL of 0.200 M aqueous solution.

Marks
4

Answer:

Calculate the time required (in minutes) to deposit 7.0 g of silver from a 0.200 M silver nitrate solution using a current of 4.5 A.

Answer:

- A lead-acid battery has the following shorthand notation:



Which component of the battery is the anode?

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

Which component of the battery is the cathode?

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

4

Marks
4

- When “dry ice”, solid carbon dioxide, is heated to 400 K it becomes gaseous. An 88.0 g sample of solid carbon dioxide is placed into a sealed 100 L container that is initially at a pressure of 1.00 atm and a temperature of 298 K. The container is heated to 400 K. What will be the final pressure inside the container?

Answer:

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, $k_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$

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

0 °C = 273 K

1 L = 10⁻³ m³

1 Å = 10⁻¹⁰ m

1 eV = 1.602 × 10⁻¹⁹ J

1 Ci = 3.70 × 10¹⁰ Bq

1 Hz = 1 s⁻¹

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
$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Au}(\text{s})$	+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
$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{Mn}^{3+} + 2\text{H}_2\text{O}$	+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
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-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> $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $4.5k_B T = hc/\lambda$ $E = Z^2 E_R (1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$	<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> $t_{1/2} = \ln 2/\lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ $^{14}\text{C age} = 8033 \ln(A_0/A_t)$	<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>Polymers</p> $R_g = \sqrt{\frac{nl_0^2}{6}}$	<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 2006

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 NIوبيUM 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]									

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]
--	--------------------------------------	---	-------------------------------------	---	---	---	--------------------------------------	---	---	---	--	--	---	---