

CHEM1612 - CHEMISTRY 1B (PHARMACY)

SECOND SEMESTER EXAMINATION

CONFIDENTIAL

NOVEMBER 2005

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		SID NUMBER	
OTHER NAMES		TABLE NUMBER	

OFFICIAL USE ONLY

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 20 pages of examinable material.
- Complete 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 question of the short answer section 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 sheets.
- Pages 17, 19 and 24 are for rough working only.

Multiple choice section

		Marks	
Pages	Max	Gained	
2-11	42		

Short answer section

Page	Marks		Marker
	Max	Gained	
12	10		
13	5		
14	6		
15	6		
16	6		
18	6		
20	6		
21	6		
22	4		
23	3		
Total	58		

- Complete the following table. H₂O is given as an example.

Marks
4

Species	Central atom	Number of nonbonding pairs on central atom	Hybridisation of central atom	Geometry of molecule	Polarity of molecule
H ₂ O	O	2	<i>sp</i> ³	bent	polar
HCOOH	C				
HCN	C				

- The energy difference between the $n = 3$ state and the $n = 2$ state in hydrogen is 3.03×10^{-19} J. What is the wavelength of light emitted when an electron moves from the $n = 3$ to the $n = 2$ state?

2

	Answer:
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- Explain the difference between the electron affinity and electronegativity of an atom.

2

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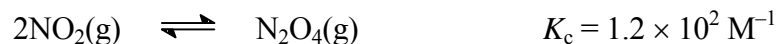
- In terms of the quantum theory of the electron, explain why electrons involved in covalent bonds between atoms have lower energy than they do when located on the separated atom.

2

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Marks
5

- A mixture of 0.500 mol of $\text{NO}_2(\text{g})$ and 0.500 mol of $\text{N}_2\text{O}_4(\text{g})$ is allowed to reach equilibrium in a 10.0 L vessel maintained at 298 K. The equilibrium is described by the equation below. $\Delta H^\circ = -15 \text{ kJ mol}^{-1}$ for the forward reaction.



Show that the system is at equilibrium when the concentration of $\text{NO}_2(\text{g})$ is 0.023 M.

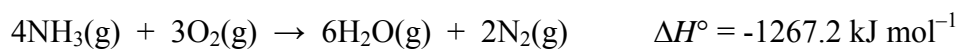
Discuss the effect an increase in temperature, at constant volume, would have on the concentration of $\text{NO}_2(\text{g})$.

State with a brief reason whether the concentration of $\text{NO}_2(\text{g})$ is increased, decreased, or unchanged when argon gas (0.2 mol) is injected while the temperature and volume remain constant.

- The final step in the industrial production of urea, $(\text{NH}_2)_2\text{CO}$, is:



Using the following data, calculate the standard enthalpy of formation of solid urea.



Marks
6

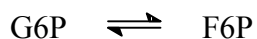
$\Delta H^\circ_f =$

The formation of urea in the industrial process is only spontaneous below 821°C .
What is the value of the entropy change ΔS° (in $\text{J K}^{-1} \text{mol}^{-1}$) for the reaction?

$\Delta S^\circ =$

Rationalise the sign of ΔS° in terms of the physical states of the reactants and products.

- A key step in the metabolism of glucose for energy is the isomerism of glucose-6-phosphate (G6P) to fructose-6-phosphate (F6P);



At 298 K, the equilibrium constant for the isomerisation is 0.510. Calculate ΔG° at 298 K.

Marks
4

Answer:

Calculate ΔG at 298 K when the $[\text{F6P}] / [\text{G6P}]$ ratio = 10.

Answer:

In which direction will the reaction shift in order to establish equilibrium? Why?

2

- The specific heat capacity of water is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ and the specific heat capacity of copper is $0.39 \text{ J g}^{-1} \text{ K}^{-1}$. If the same amount of energy were applied to a 1.0 mol sample of each substance, both initially at 25°C , which substance would get hotter? Show all working.

Answer:

Marks
3

- The active ingredient in aspirin is the monoprotic acid, acetylsalicylic acid ($\text{HC}_9\text{H}_7\text{O}_4$) that has a K_a of 3.3×10^{-4} M at 25°C . What is the pH of a solution obtained when a tablet containing 200 mg of acetylsalicylic acid is dissolved in 125 mL of water?

Answer:

2

- A standard test for the presence of chloride ion in water involves the appearance of a precipitate of AgCl upon addition of 1 mL of AgNO_3 (0.03 M) to 100 mL of the water sample. What is the minimum concentration of Cl^- detectable by this method?
 $K_{sp}(\text{AgCl}) = 1.8 \times 10^{-10} \text{ M}^2$.

Answer:

1

- The fission of U-235 is initiated by the absorption of one neutron. One pathway results in the formation of I-137, two neutrons and one other isotope. What is the other isotope?

Marks
4

- Oral rehydration therapy (ORT) is a simple low-cost treatment that replaces fluid and electrolytes lost by sufferers of diarrhoea. To make the solution for ORT, 3.5 g NaCl, 2.9 g sodium citrate (which contains 1 citrate³⁻ and 3 Na⁺ ions and has a molar mass of 258 g mol⁻¹), 1.5 g KCl and 20.0 g glucose (C₆H₁₂O₆) are dissolved in water to make 1.0 L of solution. What is the osmotic pressure (in mmHg) of this solution at body temperature (37 °C)?

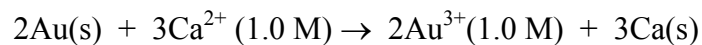
Answer:

This pressure is about the same as the osmotic pressure of blood. The calorie content of the solution can be increased by adding either more glucose or a polymer of glucose. Which would be preferable? Give a brief reason.

- Draw all of the geometric isomers for the complex ion [CoI₂(NH₃)₄]⁺. Label each isomer with its systematic name.

2

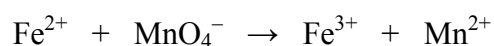
- Calculate the standard free-energy change for the following reaction at 298 K.



Marks
2

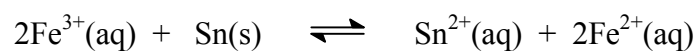
Answer:

Complete and balance the following equation for the reaction between iron(II) ions and permanganate ions in an acidic solution.



2

- What is the value of the equilibrium constant for the following reaction at 298 K?



2

Answer:

- If a medical procedure calls for 1.0 mg of ^{128}Ba , how much isotope would be required to be able to use it exactly one week later? The half life of ^{128}Ba is 2.43 days.

Marks
2

Answer:

- Will a precipitate form when 200 mL of 0.0040 M BaCl_2 is added to 600 mL of 0.0080 M K_2SO_4 ? Show all working. K_{sp} for $\text{BaSO}_4 = 1.1 \times 10^{-10} \text{ M}^2$.

2

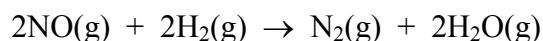
Answer:

- Complete the following table.

2

Formula	Systematic name
$[\text{Pt}(\text{NH}_3)_4]\text{Cl}_2$	
NaH_2PO_4	
	lead(II) phosphate
	magnesium hydroxide-2-water

- Consider the results of the following set of experiments studying the rate of the reaction of nitric oxide with hydrogen at 1280 °C.



Experiment #	[NO] / M	[H ₂] / M	Initial Rate / M s ⁻¹
1	5.0×10^{-3}	2.0×10^{-3}	1.3×10^{-5}
2	1.0×10^{-2}	2.0×10^{-3}	5.2×10^{-5}
3	1.0×10^{-2}	4.0×10^{-3}	1.0×10^{-4}

Write the rate law expression.

Rate =

Calculate the rate constant, k . Include units in your answer.

k =

What is the rate of the reaction when [NO] is 1.2×10^{-2} M and [H₂] is 6.0×10^{-3} M?

Rate =

Marks
4

-
- Describe how hydrophilic and hydrophobic colloids are stabilised in water.

Marks
3

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

CHEM1612 - CHEMISTRY 1B (PHARMACY)
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

CHEM1612 - CHEMISTRY 1B (PHARMACY)**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

CHEM1612 - CHEMISTRY 1B (PHARMACY)

Useful formulas

<p>Quantum Chemistry</p> $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $4.5k_B T = hc/\lambda$ $E = Z^2 E_R (1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$	<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>Acids and Bases</p> $\text{p}K_w = \text{pH} + \text{pOH} = 14.00$ $\text{p}K_w = \text{p}K_a + \text{p}K_b = 14.00$ $\text{pH} = \text{p}K_a + \log\{[A^-] / [\text{HA}]\}$	<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> $t_{1/2} = \ln 2 / k$ $k = A e^{-E_a/RT}$ $\ln[A] = \ln[A]_0 - kt$ $\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$
<p>Electrochemistry</p> $\Delta G^{\circ} = -nFE^{\circ}$ $\text{Moles of } e^- = It/F$ $E = E^{\circ} - (RT/nF) \times 2.303 \log Q$ $= E^{\circ} - (RT/nF) \times \ln Q$ $E^{\circ} = (RT/nF) \times 2.303 \log K$ $= (RT/nF) \times \ln K$ $E = E^{\circ} - \frac{0.0592}{n} \log Q \text{ (at } 25^{\circ}\text{C)}$	<p>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> $\text{If } ax^2 + bx + c = 0, \text{ then } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $\ln x = 2.303 \log x$

PERIODIC TABLE OF THE ELEMENTS

November 2005

CHEMI1612

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]									

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 YTTERIUM Yb 173.04	71 LUTETIUM Lu 174.97
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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 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]
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89/07(b)