

Topics in the November 2012 Exam Paper for CHEM1102

Click on the links for resources on each topic.

2012-N-2:

- [Weak Acids and Bases](#)

2012-N-3:

- [Weak Acids and Bases](#)
- [Calculations Involving \$pK_a\$](#)

2012-N-4:

- [Physical States and Phase Diagrams](#)
- [Intermolecular Forces and Phase Behaviour](#)

2012-N-5:

- [Coordination Chemistry](#)

2012-N-6:

- [Physical States and Phase Diagrams](#)
- [Crystal Structures](#)
- [Periodic Trends in Aqueous Oxide](#)

2012-N-7:

- [Periodic Trends in Aqueous Oxide](#)
- [Crystal Structures](#)

2012-N-8:

- [Solubility Equilibrium](#)

2012-N-9:

- [Kinetics](#)

2012-N-10:

- [Aldehydes and Ketones](#)
- [Alcohols](#)
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- [Carboxylic Acids and Derivatives](#)

2012-N-11:

- [Amines](#)
- [Organic Halogen Compounds](#)
- [Carboxylic Acids and Derivatives](#)

2012-N-12:

- [Stereochemistry](#)
- [Synthetic Strategies](#)

2012-N-13:

- [Alkenes](#)

- Aldehydes and Ketones
- Synthetic Strategies
- Organic Halogen Compounds

2012-N-14:

- Alkanes

2012-N-15:

- Alkenes
- Stereochemistry

THE UNIVERSITY OF SYDNEY

CHEMISTRY 1B - CHEM1102
SECOND SEMESTER EXAMINATION

CONFIDENTIAL**NOVEMBER 2012****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 question of the short answer section 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.
- Pages 16 and 24 are for rough working only.

OFFICIAL USE ONLY**Multiple choice section**

Marks		
Pages	Max	Gained
2-8	29	

Short answer section

Page	Marks		Marker
	Max	Gained	
9	4		
10	4		
11	5		
12	9		
13	4		
14	3		
15	6		
17	3		
18	6		
19	4		
20	7		
21	6		
22	4		
23	6		
Total	71		

- What is the pH of a 0.100 M solution of sodium acetate?
The pK_a of acetic acid is 4.76.

Marks
4

pH =

What is the ratio of acetate ion to acetic acid in this solution?

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

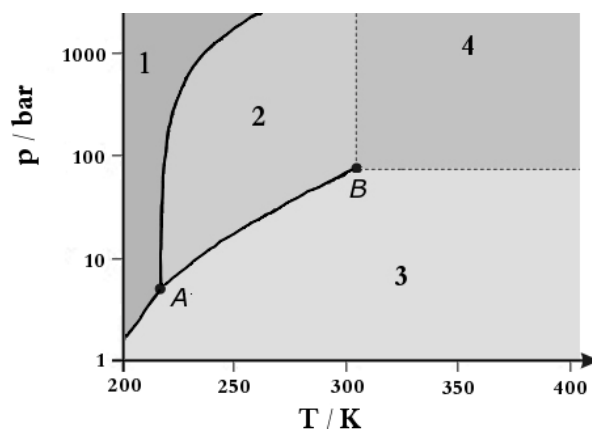
- Citric acid, $\text{C}_6\text{H}_8\text{O}_7$, has three $\text{p}K_{\text{a}}$ values: $\text{p}K_{\text{a}1} = 3.13$, $\text{p}K_{\text{a}2} = 4.76$ and $\text{p}K_{\text{a}3} = 6.40$. Explain, giving exact volumes and concentrations, how to make 1.0 L of a citrate-based buffer with pH 5.58.

Marks**4**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- The phase diagram of carbon dioxide is shown below.

Marks
5



Identify the four phases, shown as 1 - 4, in the phase diagram.

1

--

2

--

3

--

4

--

What names are given to the two points A and B?

A

--

B

--

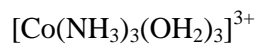
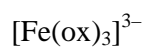
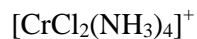
What are the physical characteristics of carbon dioxide in phase 4?

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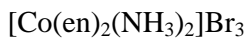
Why is the line between phases 1 and 2 almost vertical at pressures below 100 bar?

--

- The following three complex ions can all exhibit isomerism. Name the type of isomerism involved in each case and draw the structures of the isomeric pairs.
ox = oxalate = $\text{C}_2\text{O}_4^{2-}$

Marks
9

- Give the systematic name of each of the following compounds.
en = ethylenediamine = 1,2-diaminoethane = $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$

3

- What are the structural differences between graphite and diamond and how do these differences impact on their physical properties? Mention at least three physical properties.

Marks
3

- Describe the periodic trends of **either** atomic radius **or** of ionisation energy. Explain the trend in the property selected.

1

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- Order **either one** of the two following sets of oxides in terms of increasing acidity. Explain the reasons for your order.

1. HBrO_4 , H_3AsO_4 , H_2SeO_4 2. HClO_2 , HClO , HClO_4 , HClO_3 .**Marks****2**

- A binary alloy has a face-centered cubic structure with atoms of element A in the faces and atoms of element B at the corners. What is the formula of the alloy? Explain your reasoning.

1

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- What is the solubility of scandium hydroxide, $\text{Sc}(\text{OH})_3$, ($K_{\text{sp}} = 2 \times 10^{-30}$) in water? Give your answer in g per 100 mL.

Marks
2

Answer:

- How does the interplay of ΔH and ΔS affect the spontaneity of the phase change between solid and liquid water?

4

- Consider the reaction $A(g) + B(g) + C(g) \rightarrow D(g)$ for which the following data were obtained at 25 °C.

Marks
3

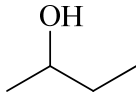
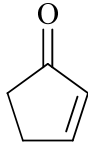
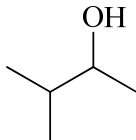
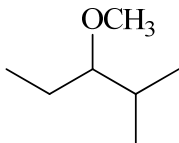
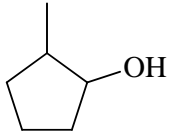
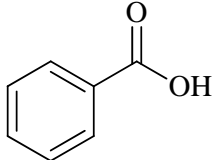
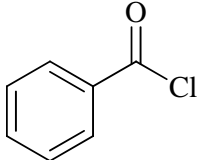
Experiment	Initial [A] (mol L ⁻¹)	Initial [B] (mol L ⁻¹)	Initial [C] (mol L ⁻¹)	Initial rate (mol L ⁻¹ s ⁻¹)
1	0.0500	0.0500	0.1000	6.25×10^{-3}
2	0.1000	0.0500	0.1000	1.25×10^{-2}
3	0.1000	0.1000	0.1000	5.00×10^{-2}
4	0.0500	0.0500	0.2000	6.25×10^{-3}

Write the rate law and calculate the value of the rate constant.

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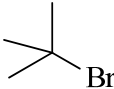
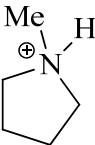
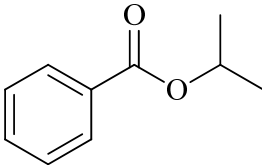
- Complete the following table.

Marks
6

STARTING MATERIAL	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
	1. NaBH ₄ 2. H ⁺ /H ₂ O	
	Cr ₂ O ₇ ²⁻ /H ⁺	
	dilute H ₂ SO ₄	
	1. NaOH 2. CH ₃ Br	
	concentrated H ₂ SO ₄	
		

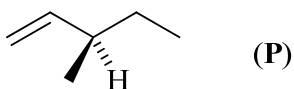
- Draw the structure of the organic product(s) formed when each of the following compounds is treated with 4 M sodium hydroxide. The first two reactions proceed at room temperature; the last one requires heating.

Marks
4

Compound	Organic Product(s)
	
	
	

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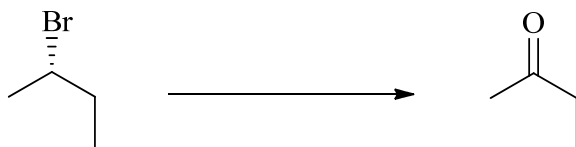
- Consider compound (**P**), whose structure is shown below.

**Marks****4**

Give the full name of compound (**P**) that unambiguously describes its stereochemistry.

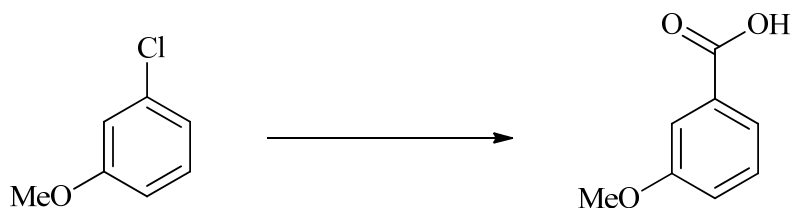
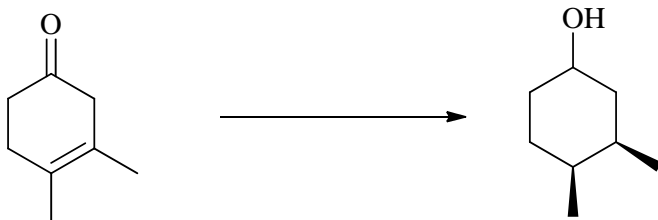
When compound (**P**) reacts with bromine (Br_2), two stereoisomers are formed. Draw the structure of both products and label all stereogenic centres appropriately.

- Devise a synthesis of the following compound from the starting material indicated. Note that more than one step will be required. Indicate all necessary reagents and the constitutional formulas of any intermediate compounds.

3

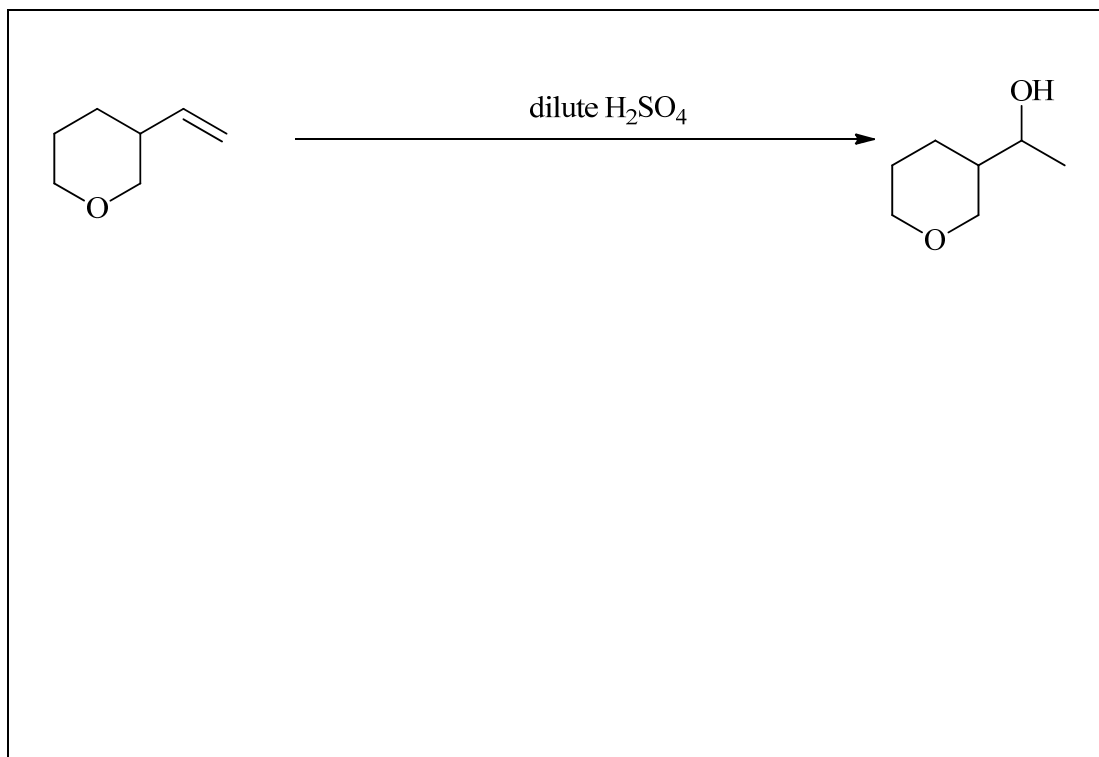
- Devise a synthesis of the following compounds from the starting materials indicated. Note that more than one step will be required. Indicate all necessary reagents and the constitutional formulas of any intermediate compounds.

Marks
6



- Complete the mechanism for the following reaction. Give the structure of the carbocation intermediate and indicate (using curly arrows) all the bonding changes that occur.

Marks
4



THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- When HBr reacts with 1-pentene, three products, **L**, **M** and **N**, are formed. **L** and **M** are enantiomers, whilst **L** and **N** (and **M** and **N**) are constitutional isomers. Give the structures of these products and explain how they form? Discuss the relative amounts of each product, paying attention to the regioselectivity and stereoselectivity of the reaction.

Hint: You need to discuss important aspects of the reaction mechanism, including the relative stabilities of any intermediates, but you do not need to give the full mechanism using curly arrows.

Marks**6**

L	M	N

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CHEM1102 - CHEMISTRY 1B**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

CHEM1102 - CHEMISTRY 1B*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
$\text{BiO}^+(\text{aq}) + 2\text{H}^+(\text{aq}) + 3\text{e}^- \rightarrow \text{Bi}(\text{s}) + \text{H}_2\text{O}$	+0.32
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+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
$\text{Sc}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Sc}(\text{s})$	-2.09
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-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

CHEM1102 - CHEMISTRY 1B*Useful formulas*

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

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 YTTRIUM 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]	110 DARMSTADTIUM 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]