

Topics in the June 2013 Exam Paper for CHEM1903

Click on the links for resources on each topic.

2013-J-2:

- [Nuclear and Radiation Chemistry](#)

2013-J-3:

- [Filling Energy Levels in Atoms Larger than Hydrogen](#)
- [Periodic Table and the Periodic Trends](#)

2013-J-4:

- [Band Theory - MO in Solids](#)

2013-J-5:

- [Bonding in O₂, N₂, C₂H₂, C₂H₄ and CH₂O](#)

2013-J-6:

- [Gas Laws](#)

2013-J-7:

- [Lewis Structures](#)
- [VSEPR](#)

2013-J-8:

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

2013-J-9:

- [Thermochemistry](#)
- [Nitrogen Chemistry and Compounds](#)
- [Types of Intermolecular Forces](#)

2013-J-10:

- [Chemical Equilibrium](#)

2013-J-11:

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

2013-J-12:

- [First and Second Law of Thermodynamics](#)

2221(a)

THE UNIVERSITY OF SYDNEY

CHEMISTRY 1A (ADVANCED) - CHEM1901

CHEMISTRY 1A (SPECIAL STUDIES PROGRAM) - CHEM1903

CONFIDENTIAL

FIRST SEMESTER EXAMINATION

JUNE 2013

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 •.
- 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 19 and 24 are for rough working only.

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Multiple choice section

		Marks	
Pages	Max	Gained	
2-10	30		

Short answer section

Page	Marks		Marker
	Max	Gained	
11	8		
12	6		
13	7		
14	4		
15	4		
16	9		
17	5		
18	5		
20	2		
21	4		
22	8		
23	8		
Total	70		
Check Total			

- Calculate the activity (in Bq) of a 1.00 g sample of $^{137}\text{Cs}^{131}\text{I}$, if the half lives of the caesium and iodine are 30.17 years and 8.02 days respectively.

Marks
8

Answer:

Both nuclides in $^{137}\text{Cs}^{131}\text{I}$ are beta emitters, and the daughter nuclides are stable. Describe the sample after it has been melted and allowed to resolidify after (a) 3 months and (b) 300 years.

<ul style="list-style-type: none">Write down the ground state electron configurations for the following species. Na is given as an example.		Marks 4
Na	[Ne] $3s^1$	
K		
As		
Sr		
C ⁺		
Name the elements described by the following configurations.		2
[Kr] $5s^2 4d^6$		
[Xe] $6s^2 5d^1 4f^{11}$		
<ul style="list-style-type: none">The Periodic Table as arranged by Mendeleev allows us to make predictions about the behaviours of elements based on those around them. Briefly describe why the Periodic Table works?		

THIS QUESTION CONTINUES ON THE NEXT PAGE.

Carbon, silicon, germanium and tin all adopt the diamond structure. Diamond has a band gap of 5.5 eV, while silicon absorbs wavelengths shorter than 1100 nm. Predict the band gaps of germanium and tin.

Marks
7

Predict the band gap of SiC, which also has a diamond like structure, but with Si bonded to 4 C atoms, and C bonded to 4 Si atoms.

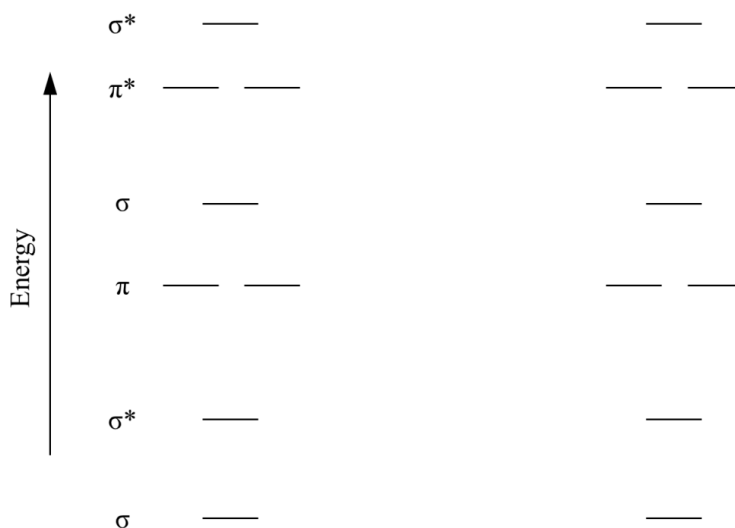
Use the information in the following table to predict the density of tin.

Element	Atomic Mass	Density (g cm^{-3})	Bond length (pm)
Ge	72.64	5.323	244
Sn	118.7		280.

Answer:

- Oxygen exists in the troposphere as a diatomic molecule.

Marks
4



- (a) Using arrows to indicate relative electron spin, fill the left-most **valence** orbital energy diagram for O_2 , obeying Hund's Rule.
- (b) Indicate on the right-most **valence** orbital energy diagram the lowest energy electronic configuration for O_2 which has no unpaired electrons.

Suggest a heteronuclear diatomic species, isoelectronic with O_2 , that might be expected to have similar spectroscopic behaviour.

The blue colour of liquid O_2 arises from an electronic transition whereby one 635 nm photon excites two molecules to the state indicated by the configuration in (b) *at the same time*. What wavelength photon would be emitted by one molecule returning from this state to the ground state?

Answer:

THIS QUESTION CONTINUES ON THE NEXT PAGE.

The density of liquid oxygen is 1.141 g cm^{-3} . Calculate its molarity and compare to the molarity of oxygen in air. Air consists of 21% oxygen.		Marks 4
[O ₂ (l)]:	[O ₂ (g)]:	
A 50.0 mL sample of liquid oxygen is transferred to an evacuated 1.25 L container and allowed to warm to room temperature (25 °C). What is the final pressure inside the container?		
		Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- Complete the following table on the given oxides of nitrogen. Indicate the charge on all atoms with non-zero formal charge.

Marks
9

Molecule	Lewis Structure	Shape of molecule
NO ₂		
N ₂ O		
NO ₃		

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- The atmosphere of Venus contains 96.5 % CO₂ at 95 atm of pressure, leading to an average global surface temperature of 462 °C. The energy density of solar radiation striking Venus is 2625 J m⁻² s⁻¹. The radius of Venus is 6052 km, and the average albedo (the fraction of solar radiation reflected back into space) of its surface is 0.90. Calculate the magnitude of the greenhouse effect on Venus.

Marks
5

Answer:

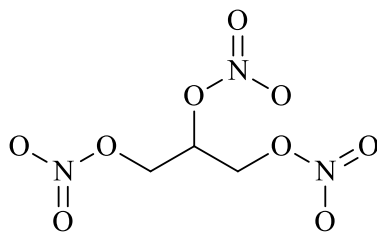
The main absorption bands of CO₂ lie in the energy range 600 – 750 cm⁻¹. What range of wavelengths (in nm) corresponds to this energy range?

Sketch the emission spectrum of Venus on the axes below. Note the wavelength of maximum intensity, and point out any other important features.

Intensity

Wavelength (nm)

- The structural formula of nitroglycerine, $C_3H_5N_3O_9$, is shown below.



The boiling point of nitroglycerine is $50\text{ }^{\circ}\text{C}$. What is the most important type of intermolecular force contributing to keeping nitroglycerine in the liquid state at room temperature, and which atoms in particular are involved?

Write a balanced equation for the explosive decomposition of liquid nitroglycerine. The products are water, carbon dioxide, nitrogen and oxygen.

The standard enthalpy change associated with this explosive decomposition is -1414 kJ mol^{-1} . What other factor(s) would contribute to the free energy released in the decomposition of nitroglycerine?

Briefly describe a calorimetry experiment that could reliably measure the enthalpy of decomposition of nitroglycerine.

Marks
5

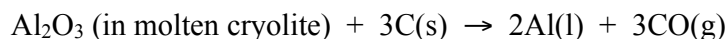
- The vapour pressure of mercury above its liquid at 25 °C is 0.265 Pa. Calculate the free energy of formation (in kJ mol^{-1}) of gaseous mercury at 25 °C.

Marks
2

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

- The principal chemical reaction in the Hall process, used to refine aluminium from its oxide, is:



The free energy change for this reaction is $\Delta G^\circ = 594 \text{ kJ mol}^{-1}$ at $1000 \text{ }^\circ\text{C}$.

Recycling aluminium essentially only requires enough energy to melt it. The melting point of aluminium is $660 \text{ }^\circ\text{C}$, its heat of fusion is 10.7 kJ mol^{-1} and its heat capacity is $0.900 \text{ J K}^{-1} \text{ g}^{-1}$. Calculate the percentage of energy saved by recycling aluminium vs. refining it from Al_2O_3 . (Assume that the ambient temperature is $25 \text{ }^\circ\text{C}$.)

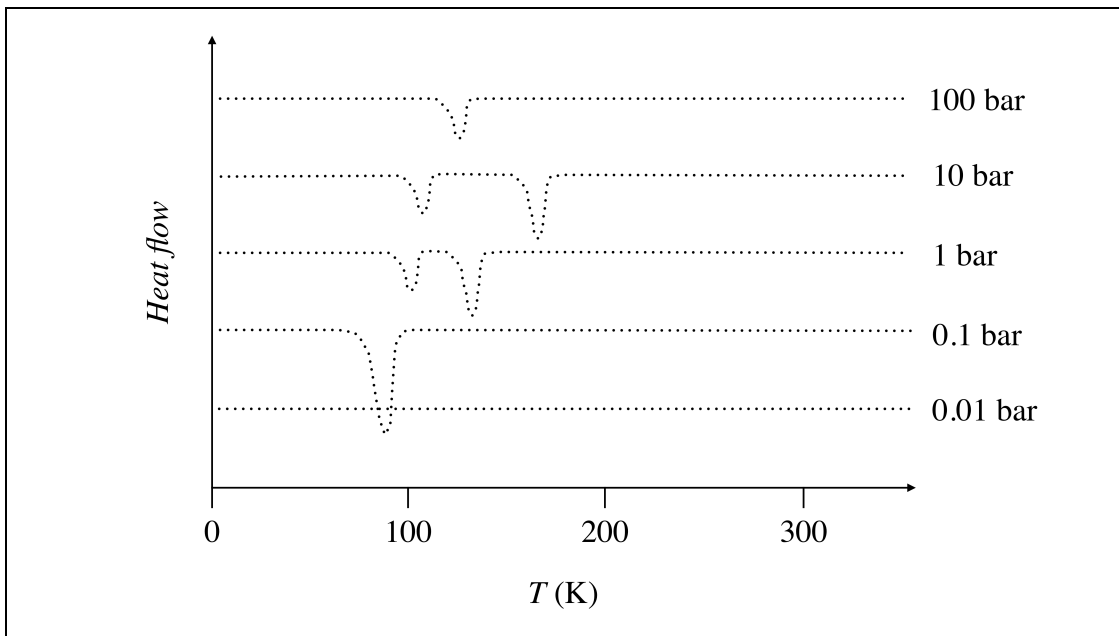
Marks**4**

Answer:

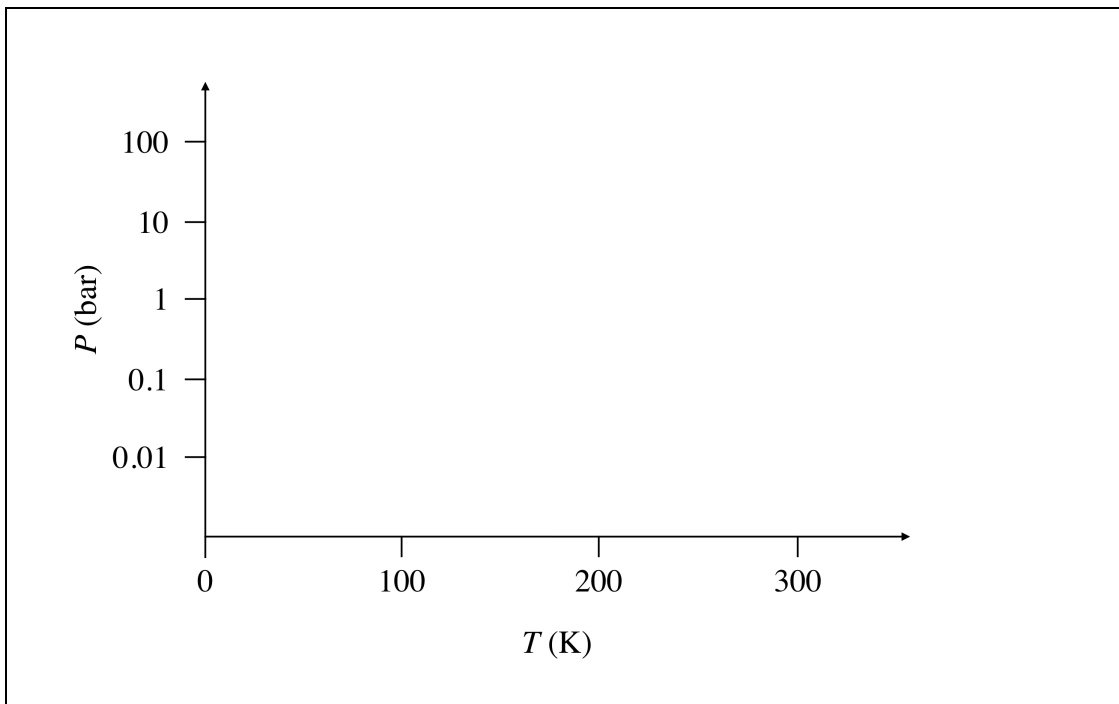
THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
8

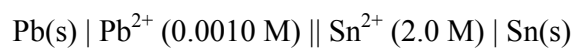
- Differential scanning calorimetry (DSC) is an experimental technique that measures the temperature of a sample as a function of the heat supplied to it. Negative or positive peaks on a DSC curve therefore indicate endothermic or exothermic processes respectively. The figure below shows a series of DSC curves collected for methane at different pressures. The scales of all the heat flow curves are the same, but they have been offset from zero for clarity. Clearly identify the type of phase change associated with every peak in the DSC curve.



Use the DSC data shown to sketch a pressure-temperature phase diagram on the graph below (note that pressure is on a log scale). Label all the important regions of the phase diagram.



- Consider the following aqueous voltaic cell at 25 °C:



Write balanced equations for the reactions occurring at the anode, cathode and overall.

anode:

cathode:

overall:

Calculate the potential of the cell under the stated conditions.

Marks
8

Answer:

What will be the concentrations of $\text{Pb}^{2+}(\text{aq})$ and $\text{Sn}^{2+}(\text{aq})$ in the cell when it comes to equilibrium?

$[\text{Pb}^{2+}(\text{aq})] =$

$[\text{Sn}^{2+}(\text{aq})] =$

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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 = 1.013 bar | 1 Ci = 3.70 × 10 ¹⁰ 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 × 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
10 ¹²	tera	T

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Standard Reduction Potentials, E°

Reaction	<i>E° / V</i>
$\text{Co}^{3+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Co}^{2+}(\text{aq})$	+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
$\text{NO}_3^{-}(\text{aq}) + 10\text{H}^{+}(\text{aq}) + 8\text{e}^{-} \rightarrow \text{NH}_4^{+}(\text{aq}) + 3\text{H}_2\text{O}$	+0.88
$\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$	+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
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Pb}(\text{s})$	-0.126
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Sn}(\text{s})$	-0.136
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Ni}(\text{s})$	-0.24
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Co}(\text{s})$	-0.28
$\text{Cd}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cd}(\text{s})$	-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

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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> $E = E^\circ - (RT/nF) \times \ln Q$ $E^\circ = (RT/nF) \times \ln K$ $E = E^\circ - \frac{0.0592}{n} \log Q \text{ (at 25 }^\circ\text{C)}$
<p>Acids and Bases</p> $\text{pH} = -\log[\text{H}^+]$ $\text{p}K_w = \text{pH} + \text{pOH} = 14.00$ $\text{p}K_w = \text{p}K_a + \text{p}K_b = 14.00$ $\text{pH} = \text{p}K_a + \log\{[\text{A}^-] / [\text{HA}]\}$	<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> $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G = \Delta G^\circ + RT \ln Q$ $\Delta G^\circ = -RT \ln K$ $\Delta_{\text{univ}} S^\circ = R \ln K$ $K_p = K_c \left(\frac{RT}{100} \right)^{\Delta n}$
<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	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	2 HELIUM He 4.003
3 LITHIUM Li 6.941												13 ALUMINUM Al 26.98	14 SILICON Si 28.09	15 PHOSPHORUS P 30.97	16 SULFUR S 32.07	17 CHLORINE Cl 35.45	10 NEON Ne 20.18
11 SODIUM Na 22.99	12 MAGNESIUM Mg 24.31											13 ALUMINUM 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 YTRBIUM 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 LANTHANIDS	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]		104 RUTHERFORDIUM Rf [263]	105 DUBNIUM Db [268]	106 SEABORGIUM Sg [271]	107 BOHRIUM Bh [274]	108 HASSIUM Hs [270]	109 MEITNERIUM Mt [278]	110 DARMSTADTIUM Ds [281]	111 ROSGENIUM Rg [281]	112 COGNACIUM Cn [285]		114 FLEROVIUM Fl [289]				116 LIVERMORIUM Lv [293]

LANTHANIDS

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
LANTHANUM La 138.91	CERIUM Ce 140.12	PRASEODYMIUM Pr 140.91	NEODYMIUM Nd 144.24	PROMETHIUM Pm [144.9]	SAMARIUM Sm 150.4	EUROPIUM Eu 151.96	GADOLINIUM Gd 157.25	TERBIUM Tb 158.93	DYSPROSIUM Dy 162.50	HOLMIUM Ho 164.93	ERBIUM Er 167.26	THULIUM Tm 168.93	YTERBIUM Yb 173.04	LUTETIUM Lu 174.97
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 MEISNERIUM Md [256.1]	102 NOBELIUM No [259.1]	103 LAWRENCIUM Lr [260.1]

ACTINIDS