School of Chemistry, UNIVERSITY OF KWAZULU-NATAL
SUBJECT, COURSE & CODE: CHEM099 and CHEM199 :FOUNDATION CHEMISTRY
NOVEMBER 2008 EXAMINATION

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Duration: 3 Hours Total Marks: 100

Instructions to Candidates:

- Answer all 5 questions on the paper provided and show your working clearly. Marks are given in brackets after each question and all questions are marked out of 20.
- The question paper consists of 12 pages including a Periodic Table, a Data Sheet and Electronegativity values
- Please check that you have them all.

Question One [20 marks]

1.1 Sodium azide (NaN_3) is used in airbags in cars. In a collision it decomposes explosively, releasing nitrogen gas. This gas inflates the airbag, protecting the passengers from injury. The reaction that occurs is as follows:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

(a) What is the mass (in grams) of 1 mole of sodium azide, NaN_3?

(0.5)

(b) Calculate the percentage by mass of sodium present in sodium azide.

(1.5)

(c) If the airbag contains 100 g of sodium azide, determine the number of nitrogen atoms present.

(4)

(d) If 1.39×10^{24} molecules of nitrogen gas were released to inflate the airbag, what volume would this gas occupy at 25 °C and 1 atm?

(2)

1.2 Concentrated nitric acid (HNO_3) has a concentration of 0.650 g/ml. What volume of concentrated nitric acid is needed to make a 2.00 dm^3 dilute solution of 0.1000M HNO_3?

(3)

1.3 Researchers discovered a compound which was useful for the treatment of malaria. Analysis by a chemist found that this compound contains 74.0 % carbon, 7.5 % hydrogen, 8.6 % nitrogen and the remainder was oxygen.

(a) Define the following terms:

(i) Empirical formula

(1)

(ii) Molecular formula

(1)

(b) Determine the empirical formula of the compound.

(5)

(c) The compound was named *Quinine*, and its molecular mass was found to be 325 g/mol. What is its molecular formula?

(2)

Question 2 [20 marks]

2.1 Silicon tetrachloride is used in the electronic industry to make elemental silicon for computer chips. Silicon tetrachloride is prepared from silicon dioxide, graphite and chlorine gas according to the following equation:

$$SiO_2(s) + 2C(s) + 2Cl_2(g) \rightarrow SiCl_4(l) + 2CO(g)$$

(a) Define limiting reagent and excess reagent.

(2)

(b) If 57.3 g of silicon dioxide and 24.3 g of carbon are mixed and an unlimited stream of chlorine gas is supplied, what mass of silicon tetrachloride could be obtained?

(5)

(c) If the reaction achieves a 95.7 % yield, what would be the actual mass of silicon tetrachloride obtained?

(2)

(d) What mass (in grams) of the solid reactants remain?

(2)

(e) Calculate the number of particles of solid that will remain unreacted. What type of particles are these?

(2)

2.2 Silver bromide is easily prepared in the laboratory by means of a precipitation reaction according to the following balanced equation:

$$2AgNO_3(aq) + CaBr_2(aq) \rightarrow 2AgBr(s) + Ca(NO_3)_2(aq)$$

(a) Explain the phrase "precipitation reaction".

(1)

(b) Give another name under which the above reaction can be classified.

(1)

(c) Calculate the volume (in millilitres) of 0.125 M calcium bromide required to produce 1.081 g of silver bromide.

(5)

Question 3 [20 marks]

Use your Periodic Table to answer the following questions:

3.1 Consider the -2 ion of the element $_{34}X$.

(a) Which noble gas is iso-electronic with this ion?

(1)

(b) Write the abbreviated electronic configuration for this ion.

(1)

(c) Identify element X.

(1)

3.2 Consider the element whose spectroscopic electronic configuration is as follows: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

(a) Which is the outermost energy level?

(1)

b) Which energy sub-level has the highest energy?

(1)

3.3 (a) State Hund's rule of Maximum Multiplicity.

(1)

(b) Define the term "orbital".

(1)

(c) In which group(s) would you find elements with 2 half-filled p orbitals?

(1)

(d) Draw the tabular/orbital electronic configuration of chlorine and use this to determine how many unpaired electrons it has.

(1)

(e) Write the abbreviated spectroscopic electronic configuration of nickel.

(1)

(f) Write the outer shell spectroscopic electronic configuration of a period 3 element which has 5 electrons in its valence shell.

(1)

3.4 Consider the two most common isotopes of boron: B-10 and B-11. Do the isotopes of boron have the same physical and chemical properties as each other? Explain your answer.

(2)

3.5 Consider the metal in period 3 and group 13.

(a) How many core electrons does this element have?

(1)

(b) Write down its excited state spectroscopic electronic configuration.

(1)

(c) Write down the symbol for the ion of this element and its spectroscopic electronic configuration.

(2)

3.6

(a) Write down the symbol of any ion which is iso-electronic with the chloride ion.

(1)

(b) Give a reason why oxygen and magnesium form ions which are iso-electronic.

(2)

Question 4 [20 marks]

4.1 Study the following statements and correct them where necessary:

(a) Sodium bicarbonate has the formula $NaCO_3$

(2)

(b) Iron(III) sulfite has the formula $FeSO_3$

(2)

4.2 Read each of the following statements. Decide if they are true or false. If false, correct the statement.

(a) Ionic compounds always contain only electrostatic bonds.

(2)

(b) Molecular solids have relatively low melting and boiling points because they are held together by means of strong electrostatic bonds.

(2)

4.3 Covalent bonds can be classified as either polar or non-polar.

(a) Explain the difference between a polar and a non-polar bond.

(2)

(b) Classify each of the following as polar or non-polar bonds.
Show how you came to your answers.

Cl – Cl Cl – Br Cl - N Cl – H

(4)

4.4 Study the following table of compounds, and then answer the questions that follow

- Each formula can be used more than once in answering questions a to f
- Write the **full formula** for each answer
- Some questions may have more than one answer, and some may have no answer, in which case say '**none**' or '**no answer**'
- Each question is worth **one mark**
- **The mark will be assigned only if the complete answer is given**

CO_2	CH_3OH	Cu_2S
NH_4OH	Li_3N	$CaCO_3$
$SrBr_2$	$MgSO_4.7H_2O$	NaCl(aq)

(a) Write down the formula(e) for all the substances which include water.

(b) Write down the formula(e) for all the tri-atomic formula units.

(c) Write down the formula(e) for all the ionic compounds.

(d) Write down the formula(e) for all the compounds which contain only 3 hydrogen atoms.

(e) Write down the formula(e) for compounds containing an alkali earth element(s).

(f) Write down the formula(e) for substances containing a -3 mono-atomic anion

(6)

Question 5 [20 marks]

5.1 A company is developing a new chemical moisture absorber and indicator to keep CD players dry. Cobalt(II) chloride, $CoCl_2$, is tested as a possible substance for the job. In one experiment 10.00 g of the pink hydrated $CoCl_2$ is heated in a crucible. The results of the experiment are given in the table below:

Mass of sample (g)	
After 1st heating	5.568
After 2nd heating	5.458
After 3rd heating	5.457

(a) Explain why the mass of the sample decreased.

(1)

(b) Determine the mass of water in the hydrated $CoCl_2$.

(1)

(c) Determine the empirical formula of the $CoCl_2$ hydrate.

(3)

(d) Write a balanced chemical equation for the dehydration reaction.

(1)

(e) Define the term "heating to constant mass".

(1)

(f) Provide a reason for cooling the contents of the crucible in a desiccator.

(1)

(g) Explain, with the aid of calculations, why a 3rd heating was required.

(3)

(h) Explain why a 4th heating was not necessary.

(1)

(i) You re-hydrate a small amount of the blue anhydrous $CoCl_2$ by adding a few drops of water to the sample. What observation would be made that shows a physical change?

(1)

(j) After the experimentation with the hydrated and anhydrous forms of the compound, $CoCl_2$, would it be recommended as a moisture absorber and indicator? Explain your answer.

(2)

5.2 Two students obtained the results in the table below when they heated a solid. In each case, the students observed drops of liquid forming on the sides of the test tube while heating.

Student	Mass before heating (g)	Constant mass after heating (g)
1	1.923	0.8480
2	2.004	1.281

(a) What observation suggests that the solid is a hydrated compound?

(1)

(b) Determine the percentage by mass of water in the original hydrated salt analyzed by Student 1.

(2)

(c) The samples analyzed by the students are $CuSO_4.5H_2O$ and $Na_2SO_4.10H_2O$. Determine which sample was analyzed by Student 1

(2)

PERIODIC TABLE

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminium	14 Si Silicon	15 P Phosphorus	16 S Sulphur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Caesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium									

Elements marked with * are those which do not occur naturally on Earth.

58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium *	94 Pu Plutonium *	95 Am Americium *	96 Cm Curium *	97 Bk Berkelium *	98 Cf Californium *	99 Es Einsteinium *	100 Fm Fermium *	101 Md Mendelevium *	102 No Nobelium *	103 Lw Lawrencium *

key: Atomic Number 6, Symbol C, Carbon

TABLE OF RELATIVE ATOMIC MASSES (Based on Carbon-12)

	Symbol	Atomic No.	Atomic Mass
Actinium	Ac	89	[227]
Aluminium	Al	13	26.98
Americium	Am	95	[243]*
Antimony	Sb	51	121.75
Argon	Ar	18	39.95
Arsenic	As	33	74.92
Astatine	At	85	[210]
Barium	Ba	56	137.34
Berkelium	Bk	97	[247]
Beryllium	Be	4	9.012
Bismuth	Bi	83	208.98
Boron	B	5	10.81
Bromine	Br	35	79.90
Cadmium	Cd	48	112.41
Calcium	Ca	20	40.08
Californium	Cf	98	[251]
Carbon	C	6	12.01
Cerium	Ce	58	140.12
Cesium	Cs	55	132.91
Chlorine	Cl	17	35.45
Chromium	Cr	24	52.00
Cobalt	Co	27	58.93
Copper	Cu	29	63.55
Curium	Cm	96	[247]
Dysprosium	Dy	66	162.50
Einsteinium	Es	99	[252]
Erbium	Er	68	167.26
Europium	Eu	63	151.96
Fermium	Fm	100	[257]
Fluorine	F	9	190.00
Francium	Fr	87	[223]
Gadolinium	Gd	64	157.25
Gallium	Ga	31	69.72
Germanium	Ge	32	72.61
Gold	Au	79	196.97
Hafnium	Hf	72	178.49
Helium	He	2	4.00
Holmium	Ho	67	164.93
Hydrogen	H	1	1.01
Indium	In	49	114.82
Iodine	I	53	126.90
Iridium	Ir	77	192.22
Iron	Fe	26	55.85
Krypton	Kr	36	83.80
Lanthanum	La	57	138.91
Lawrencium	Lr	103	[260]
Lead	Pb	82	207.20
Lithium	Li	3	6.94
Lutetium	Lu	71	174.97
Magnesium	Mg	12	24.31
Manganese	Mn	25	54.94
Mendelevium	Md	101	[258]
Mercury	Hg	80	200.59
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24
Neon	Ne	10	20.18
Neptunium	Np	93	[237]58
Nickel	Ni	28	.69
Niobium	Nb	41	92.91
Nitrogen	N	7	14.01
Nobelium	No	102	[259]
Osmium	Os	76	190.20
Oxygen	O	8	16.00
Palladium	Pd	46	106.42
Phosphorus	P	15	30.97
Platinum	Pt	78	195.08
Plutonium	Pu	94	[244]
Polonium	Po	84	[210]
Potassium	K	19	39.10
Praseodymium	Pr	59	140.91
Promethium	Pm	61	[145]
Protactinium	Pa	91	231.04
Radium	Ra	88	226.03
Radon	Rn	86	[222]
Rhenium	Re	75	186.21
Rhodium	Rh	45	102.91
Rubidium	Rb	37	85.47
Ruthenium	Ru	44	101.07
Samarium	Sm	62	150.36
Scandium	Sc	21	44.96
Selenium	Se	34	78.96
Silicon	Si	14	28.09
Silver	Ag	47	107.87
Sodium	Na	11	22.99
Strontium	Sr	38	87.62
Sulfur	S	16	32.07
Tantalum	Ta	73	180.95
Technetium	Tc	43	[98]
Tellurium	Te	52	127.60
Terbium	Tb	65	158.93
Thallium	Tl	81	204.37
Thorium	Th	90	232.04
Thulium	Tm	69	168.93
Tin	Sn	50	118.71
Titanium	Ti	22	47.88
Tungsten	W	74	183.85
Uranium	U	92	238.03
Vanadium	V	23	50.94
Xenon	Xe	54	131.29
Ytterbium	Yb	70	173.04
Yttrium	Y	39	88.91
Zinc	Zn	30	65.39
Zirconium	Zr	40	91.22*

A value given in brackets denotes the mass of the longest-lived or best-known isotope,

Electro-negativity values for selected elements

(in order of Atomic Number)

Element	Electro-negativity value
H	2.1
He	0
Li	0.98
Be	1.57
B	2.04
C	2.55
N	3.04
O	3.44
F	3.98
Ne	0
Na	0.93
Mg	1.31
Al	1.61
Si	1.9
P	2.19
S	2.58
Cl	3.16
Ar	0
K	0.82
Ca	1
Br	2.96