THE COLLEGE OF THE BAHAMAS

EXAMINATION

SEMESTER 01-2005

FACULTY OF PURE AND APPLIED SCIENCES
SCHOOL OF SCIENCES AND TECHNOLOGY

X NASSAU
☐ FREEPORT
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DATE AND TIME OF EXAMINATION Thursday, April 21, 2005 at 9 am

DURATION: 3 HOURS

COURSE NUMBER: Chem 115

COURSE TITLE: Introductory Chemistry

STUDENT NAME:

STUDENT NUMBER:

LECTURER'S NAME:

INSTRUCTIONS TO CANDIDATES:

This examination paper consists of 11 pages (including this instruction page). Answer ALL questions in the spaces provided on the examination paper. Students are allowed to use calculators during this examination.

PERIODIC TABLE OF THE ELEMENTS

1 H 1•0																	2 He 4•0
3 Li 6•9	4 Be 9•0											5 B 10•8	6 C 12•0	7 N 14•0	8 O 16•0	9 F 19•0	10 Ne 20•2
11 Na 23•0	12 Mg 24•3											13 Al 27•0	14 Si 28•1	15 P 31•0	16 S 32•1	17 Cl 35•5	18 Ar 39•9
19 K 39•1	20 Ca 40•1	21 Sc scandium 45•0	22 Ti titanium 47•9	23 V vanadium 50•9	24 Cr chromium 52•0	25 Mn manganese 54•9	26 Fe iron 55•8	27 Co cobalt 58•9	28 Ni nickel 58•7	29 Cu copper 63•5	30 Zn zinc 65•4	31 Ga galium 69•7	32 Ge germanium 72•6	33 As arsenic 74•9	34 Se selenium 79•0	35 Br bromine 79•9	36 Kr krypton 83•8
37 Rb rubidium 85•5	38 Sr srontium 87•6	39 Y yttrium 88•9	40 Zr zirconium 91•2	41 Nb niobium 92•9	42 Mo molybdenum 95•9	43 Tc technetium 98•9	44 Ru ruthenium 101•1	45 Rh rhodium 102•9	46 Pd paladium 106•4	47 Ag silver 107•9	48 Cd cadmium 112•4	49 In indium 114•8	50 Sn tin 118•7	51 Sb antimony 121•8	52 Te tellurium 127•6	53 I iodine 126•9	54 Xe xenon 131•3
55 Cs cesium 132•9	56 Ba barium 137•3	57 La lanthanum 138•9	72 Hf hafnium 178•5	73 Ta tantalum 180•9	74 W tungsten 183•85	75 Re rhenium 186•2	76 Os osmium 190•2	77 Ir iridium 192•2	78 Pt platinum 195•1	79 Au gold 197•0	80 Hg mercury 200•6	81 Tl thallium 204•4	82 Pb lead 207•2	83 Bi bismuth 209•0	84 Po pollonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89 Ac actinium															

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 protoactinium	92 U uranium	93 Np neptunium	94 Pu plutonium	95 Am americium	06 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

SECTION I: Multiple choice questions **The following information may be required:**

The molar volume of any gas at s.t.p. is 22.4 dm^3mol^{-1}.
Avogadro's number is 6.02×10^{23}.

1). Which one of the following contains the greatest proportion of nitrogen by mass?

	COMPOUND	RFM
A	$(NH_4)_2SO_4$	132
B	$(NH_4)_2CO_3$	96
C	NH_4NO_3	80
D	$(NH_4)_3PO_4$	149
E	NH_4Cl	53.5

(RAM of N = 14)

2) Molar mass is
- A measured in g mol^{-1}.
- B measured in g.
- C measured in mol.
- D measured in atoms.
- E unitless.

3) Which one of the following statements regarding the gases hydrogen and oxygen, under the same conditions of temperature and pressure, is true?
- A One mole of each gas will occupy a different volume at s.t.p.
- B One mole of each gas will have the same mass.
- C One mole of each gas will occupy the same volume if they are solidified.
- D One mole of each gas will occupy the same volume if they are liquefied.
- E One mole of each gas will contain the same number of molecules.

4) Which one of the following masses of anhydrous sodium carbonate (Na_2CO_3) contains 0.005 moles of this substance?
- A 0.255 g
- B 21200 g
- C 5.3 g
- D 0.53 g
- E 106 g

5) Which one of the following correctly expresses the number of moles of ammonia (NH_3) in 0.085 g of the compound?
- A 22.4
- B 22.4×0.085
- C $0.085 \div 17$
- D $17 \div 0.085$
- E 0.085×17

6) Which one of the following correctly expresses the number of molecules present in 5.6 dm^3 of sulphur dioxide gas (SO_2) at s.t.p.?
- A 6.02×10^{23}
- B $5.6 \times 6.02 \times 10^{23}$
- C $64 \times 6.02 \times 10^{23}$
- D $(5.6 \div 22.4) \times 6.02 \times 10^{23}$
- E $22.4 \times 6.02 \times 10^{23}$

7) An element Q has an atomic number of 16 and a mass number of 32. Select the correct statement.
- A An atom of Q has 32 protons, 16 electrons and 16 neutrons.
- B An atom of Q has 6 electrons in the outer shell.
- C Q reacts by losing 2 electrons from the outer electron shell.
- D Q may be found in group 3 and period 6.
- E Q has 8 electrons in the outer shell.

8) A compound consists of 22.5% phosphorus and 77.5% chlorine. Which one of the following is the correct empirical formula of the compound? (RAM P=31, Cl=35.5)
- A PCl_4
- B PCl_3
- C PCl
- D P_2Cl_3
- E P_3Cl

9) What mass of iron would contain the same number of atoms as 10 g of silicon? (RAM Fe=56, Si=28)
- A 5.0 g
- B 5.6 g
- C 2.8 g
- D 20 g
- E 10 g

10) Carbon monoxide reacts with oxygen according to the equation:

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

0.6 mol of carbon monoxide are mixed with oxygen and allowed to react. Which of the following statements is true?

A 2 mol of carbon dioxide is produced.
B 0.6 mol of carbon dioxide is produced.
C 2 mol of carbon monoxide is used up.
D 3 mol of a mixture of oxygen and carbon monoxide are formed.
E 1 mol of oxygen is used up.

11) What is the molarity of a solution prepared by dissolving 1.60 g of sodium hydroxide (RFM 40) to give 500 cm^3 of solution?

A 4.0 M
B 2.0 M
C 0.02 M
D 0.04 M
E 0.08 M

12) In which one of the following cases does NO change occur?

A Mg(s) added to $ZnSO_4(aq)$.
B Pb(s) added to $ZnSO_4(aq)$
C Pb(s) added to $AgNO_3(aq)$
D Fe(s) added to $CuSO_4(aq)$
E Fe(s) added to $Pb(NO_3)_2(aq)$

13) Which one of the following metals is least affected chemically when heated in air?

A Na B Zn C Ag D Mg E Fe

14) Dilute hydrochloric acid will react readily with all of the following EXCEPT:

A magnesium
B calcium carbonate
C sodium hydroxide
D copper
E magnesium oxide

15) Which one of the following compounds does NOT decompose when heated in a bunsen flame?

A silver oxide
B lead(II) carbonate
C calcium oxide
D copper(II) nitrate
E sodium nitrate

16) Which one of the following compounds gives oxygen as the only gaseous product on heating?

A lead(II) nitrate
B copper(II) nitrate
C calcium nitrate
D potassium nitrate
E silver nitrate

17) The element Q reacts with hydrogen to form a compound which turns damp blue litmus paper red. Select the element that behaves in this manner.

A sodium
B lithium
C carbon
D neon
E chlorine

18) Which one of the following decreases as you go down the group of alkali metals?

A atomic radius
B number of electrons
C number of protons
D ionization energy
E reactivity

19) Select the pair of substances that can be reacted together to form calcium nitrate.

A calcium and sodium nitrate
B calcium hydroxide and hydrochloric acid
C calcium carbonate and nitric acid
D water and calcium metal
E calcium nitrite and oxygen

20) A substance Z reacts vigorously with dilute sulfuric acid to release a gas G, and form a colourless solution. Gas G turns lime water milky. The most likely identities of Z and G are

A copper and sulfur dioxide
B copper and hydrogen
C zinc and carbon dioxide
D zinc carbonate and carbon dioxide
E calcium and hydrogen

21) Which one of the following ions is not normally formed?

A Fe^{2+}
B Fe^{3+}
C Ca^{+}
D Na^{+}
E Mg^{2+}

22) Element X is in group II of the periodic table. The oxide of element X is likely to be:
A acidic
B neutral
C basic
D amphoteric
E non-existent

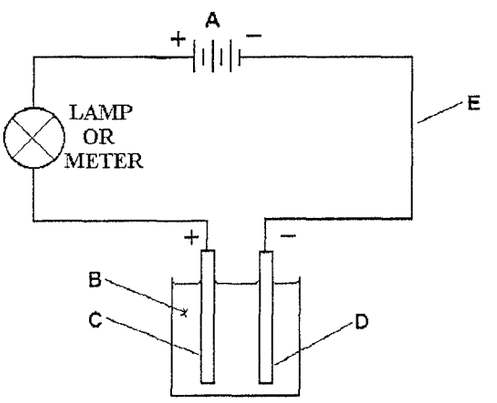
23) A metal hydroxide dissolves in water to give a strongly alkaline solution. The likely identity of this metal hydroxide is
A copper(II) hydroxide
B magnesium hydroxide
C lead(II) hydroxide
D sodium hydroxide
E aluminium hydroxide

24) Zinc oxide dissolves in both dilute hydrochloric acid and dilute sodium hydroxide solution. Zinc oxide is therefore described as
A amphoteric
B neutral
C acidic
D basic.
E soluble in water

25) When dilute sulfuric acid is electrolysed, the reaction at the cathode can be expressed as
A $2H^-(aq) \rightarrow H_2(g) + 2e^-$
B $4OH^-(aq) + 4e^- \rightarrow 2H_2O(l) + O_2(g)$
C $2SO_4^{2-}(aq) \rightarrow 2SO_3^{2-}(aq) + O_2(g)$
D $2H^+(aq) + 2e^- \rightarrow H_2(g)$
E $2SO_4^{2-}(aq) \rightarrow S_2O_8^{2-}(aq) + 2e^-$

26) An oxidising agent may be defined as a substance which is
A an electron acceptor
B an electron donor
C a proton donor
D a proton acceptor
E an oxygen acceptor

Items 27 to 29. These involve the electrolytic cell shown below.



Select, from the diagram, the appropriate label A-E for each of the following items. Use each letter as many times as necessary.

27) Which feature is the anode of the electrolytic cell?
28) Which feature is the electrolyte?
29) Which feature supplies electricity?

30) Each of the following compounds is electrolysed, first molten, and then as an aqueous solution. For which one of the following compounds would the products of electrolysis of the molten and aqueous forms most likely be the same?
A copper(II) iodide
B magnesium bromide
C potassium iodide
D sodium hydroxide
E sodium chloride

31) When the temperature at which a reaction takes place is increased, the reaction rate increases. This is because the increased temperature
A increases the number of particles with the necessary activation energy.
B enables the reacting particles to collide at the correct angle.
C lowers the activation energy for the reaction.
D enables the activated complex to be more easily converted to the products.
E prevents product molecules from changing back into reactants.

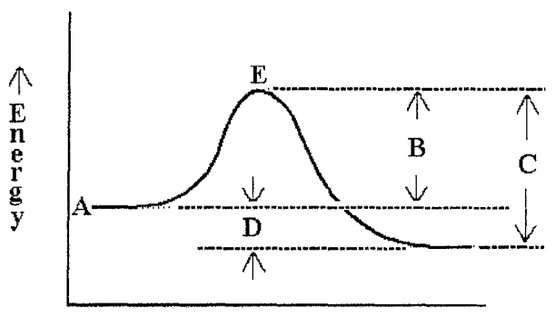
32) An equilibrium system contains dinitrogen tetroxide (pale yellow) and nitrogen dioxide (dark brown).

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ ΔH +ve
yellow brown

Which one of the following changes to a sample of the gas at equilibrium would result in a change from yellow to brown?

A increase in pressure
B increase in temperature
C addition of a catalyst
D removal of dinitrogen tetroxide by liquefaction
E lowering of the temperature

Items 33 to 36. These involve the energy profile diagram for a reversible reaction shown below.



Select, from the diagram, the appropriate label A-E for each of the following items. Use each letter as many times as necessary.

33) Activation energy of the reverse reaction.
34) Energy level of the activated complex.
35) Activation energy of the forward reaction.
36) Energy level of the reactants.

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37) A solution D has a pH of 9.0. It follows that

A D turns blue litmus paper red.
B D turns red litmus paper blue.
C D reacts with reactive metals to release a colourless gas.
D D reacts with non-metals to release a colourless gas.
E None of the above is true.

38) Which one of the following is a correct description of hydrogen?

A A gas that turns lime water milky.
B An alkaline gas with a strong smell.
C A dense brown acidic gas.
D A dense brown alkaline gas.
E A colourless odourless gas.

39) Before carrying out a flame test on a substance, it is first moistened with concentrated hydrochloric acid. For which one of the following reasons is this done?

A In order to clean the substance.
B In order to form a relatively volatile chloride of the metal.
C In order to make the substance more flammable.
D In order to remove water from the substance.
E In order to remove unwanted sodium ions.

40) Which one of the following gases will turn moist red litmus paper blue?

A oxygen.
B sulphur dioxide.
C ammonia.
D carbon dioxide.
E hydrogen.

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SECTION II: Short answer questions

Answer each of the following questions in the space provided on your question paper. Indicate clearly how you arrive at your answers. ***Underline your answers*** where appropriate

1) **RATES OF REACTION**

A scientist investigates the rate at which hydrochloric acid reacts with copper(II) carbonate. She places 100 cm^3 of 0.5 M hydrochloric acid (at room temperature) in a small beaker, which is then placed in a larger conical flask. She also places a 10.0 g sample of copper(II) carbonate powder in the conical flask by the side of the small beaker. She then seals the flask with a stopper and delivery tube connected to a gas syringe. When she is ready with a timer, she tips the flask, causing the acid to spill. There is immediate fizzing. The gas evolved is collected in the gas syringe. After 120 seconds the scientist notices that no more gas is evolved.

a) Write a balanced equation, showing states, for the reaction. (2)

b) Explain why there is "fizzing" (1)

c) What is the purpose of placing the hydrochloric acid in a small beaker? (1)

d) i) What do you expect to happen to the reaction rate if the concentration of the acid is increased? (1)

ii) Explain your answer, with reference to the collision theory. (2)

e) i) What effect, if any, would cooling the acid have on the rate of the reaction? (1)

ii) Explain your answer with reference to the collision theory. (2)

2) **THE REACTIVITY SERIES OF METALS**

This question concerns the metals magnesium, copper, zinc, and silver.

a) Place the four metals in order of decreasing reactivity, putting the most reactive first. (2)

b) Identify all of the metals which react with dilute hydrochloric acid and give equations for the reactions . (4)

c) i) Describe what you *see* when a strip of copper is placed in a solution of silver nitrate. (2)

ii) Give an equation for the reaction occurring in part i) above. (2)

d) State which **one** of the above metals has a carbonate which decomposes to the metal if heated. Give an equation for this reaction. (2)

3) **THE PERIODIC TABLE**

This question tests your knowledge of the principles embodied in the periodic table. It focuses on the chemistry of the element selenium but you are not expected to have any prior knowledge of the chemistry of this element. You should apply the principles which apply to the groups and periods of the periodic table, and to chemistry in general. The element selenium (symbol Se) is placed in group VI of the periodic table, immediately below sulphur.

a) What would you expect selenium to be, a metal or a non-metal? (1)

b) How would you expect the reactivity of selenium to compare with that of sulfur **and** oxygen? (2)

c) How would you expect the size of the selenium atom to compare

i) with the size of the sulfur atom (1)

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ii) with the size of the bromine atom. (Bromine lies immediately to the right of selenium in the periodic table.) (1)

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d) Selenium reacts with sodium to form an ionic compound. Write an ionic formula for this compound. (2)

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e) When heated in oxygen, selenium forms a solid oxide of formula SeO_3 which dissolves in water.

i) Suggest an equation for its reaction with water. (1)

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ii) How would you expect the solution to affect litmus paper? (1)

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f) Selenium forms a gaseous compound with hydrogen called hydrogen selenide.

i) What type of bonding would you expect to be present in this compound? (1)

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4) THE MOLE CONCEPT

a) How many moles of nitrogen atoms are present in 100 g of potassium nitrate given that the compound is 13.9% nitrogen. (RAM of N = 14) (2)

b) How many moles of hydrogen atoms are present in 18.5 L of hydrogen gas, measured at s.t.p.? (2)

c) What volume (in cm^3) of 0.40 M potassium chloride would be needed to obtain 0.020 mol of the salt? (2)

d) Calculate the molar mass of the compound magnesium nitrate, $Mg(NO_3)_2$? (RAM Mg =24, N=14, O =16) (1)

e) What is the total number of ions present in 0.25 moles of sodium sulfate (Na_2SO_4)? (2)

5) **ELECTROCHEMISTRY**

In each of the situations below, write balanced half equations to show firstly the process occurring at the anode and secondly the process occurring at the cathode. Indicate states where appropriate.

a) The electrolysis of molten sodium chloride.

AT ANODE:_____

AT CATHODE:_____

b) The electrolysis of dilute aqueous sodium chloride solution.

AT ANODE:_____

AT CATHODE:_____

c) The electrolysis of aqueous copper(II) sulphate solution using copper electrodes.

AT ANODE:_____

AT CATHODE:_____

6) **CHEMICAL EQUILIBRIUM**

Sulfur dioxide gas reacts with oxygen to form sulfur trioxide, according to the equation shown below:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

a) State Le Chatelier's Priciple. (2)

_____

_____

b) Predict what happens to the equilibrium position if sulfur dioxide is removed from the system. (1)

c) When the pressure on the system is decreased, it is found that the equilibrium position shifts to the left. Explain why this shift takes place. (2)

d) Predict the effect of adding oxygen to the system. (1)