UNIVERSITY OF SWAZILAND
DIPLOMA IN ENVIRONMENTAL HEALTH SCIENCE
SUPPLEMENTARY EXAMINATION PAPER 2006

TITLE OF PAPER	:	**INTEGRATED BASIC SCIENCES**
COURSE CODE	:	**HSC 103**
TIME	:	**3 HOURS**
TOTAL MARKS	:	**100 MARKS**
INSTRUCTIONS	:	**ANSWER FIVE QUESTIONS ONLY**
	:	**EACH QUESTION IS 20 MARKS**
	:	**AT LEAST TWO QUESTIONS MUST BE ANSWERED FROM EACH SECTION.**
	:	**A PERIODIC TABLE AND DATA SHEETS ARE PROVIDED WITH THIS EXAMINATION PAPER**
	:	**NO FORM OF ANY PAPER SHOULD BE BROUGHT INTO NOR TAKEN OUT OF THE EXAMINATION ROOM**
	:	**BEGIN THE ANSWER TO EACH QUESTION ON A SEPARATE SHEET OF PAPER**
	:	**ALL CALCULATIONS/WORKOUT DETAILS SHOULD BE SUBMITTED WITH YOUR ANSWER SHEET(S)**

DO NOT OPEN THIS EXAMINATION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

SECTION A

ANSWER AT LEAST TWO QUESTIONS FROM THIS SECTION

QUESTION 1

(a) A body is shot vertically with a speed of 150 m/s.

(i) What is its velocity at $t = 10$ s. **(2 marks)**

(ii) What is its velocity at $t = 20$ s. **(2 marks)**

(b) A cat jumps from the floor with an initial velocity of 5 m/s and lands on top of a table with zero vertical velocity. The initial velocity of the cat makes an angle of 40° with the horizontal.

(i) What is the height of the table from the floor? **(6 marks)**

(ii) How much time does the cat spend during the jump? **(3 marks)**

(c) A 65 kg student on an internship has to lift a box of medical supplies of mass $m = 60$ kg to a storage bin a certain distance from the ground. The student can comfortably apply a force F that is a third of his weight for a period long enough to lift the box at constant velocity. Determine whether the student can comfortably lift the box using a pulley system as shown in Figure 1. Show fully how you obtain your solution. **(7 marks)**

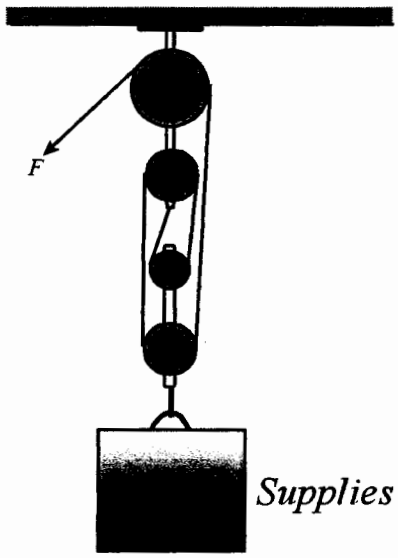

Figure 1.

QUESTION 2

(a) Water is to be pumped from a bore hole 50 m deep at a rate of 1 kg per second and discharged with a speed o

(i) How much potential energy is supplied to the water per second? **(2 marks)**

(ii) How much kinetic energy is supplied to the water per second? **(2 marks)**

(iii) What is the power of the pump? **(2 marks)**

(b) Two students on a charity project help each other to lift 20 bags of cement over a height of one metre. Each bag of cement has a mass of 50 kg.

(i) How much energy does each student spend in joules. **(2 marks)**

(ii) What is the energy spent by each student in food calories? **(2 marks)**

(iii) If each student ate a breakfast of 2 000 Calories, how many times would they have to lift sets of 20 bags of cement over the height of 1 m to shed off all the calories consumed? Would this be realistic? **(3 marks)**

(c) A flywheel of moment of inertia $I = 65$ kg m^2 is accelerated from an initial angular velocity of 1000 rpm (revolutions per minute) to a final angular velocity of 5000 rpm in 5 s.

(i) What is the initial angular velocity in radians/second? **(2 marks)**

(ii) What is the initial angular velocity in radians/second? **(2 marks)**

(iii) What is the angular acceleration of the wheel? **(2 marks)**

(ii) What is the kinetic energy of the wheel at $t = 5$ s? **(1 mark)**

QUESTION 3

(a) A circular steel wire of length 1.8 m and a cross-sectional area of 2.4×10^{-6} m^2 supports a load of 40 kg within the proportional region. Under the tension the wire stretches by 0.45 mm.

(i) What is the stress on the wire? **(2 marks)**

(ii) What is the strain on the wire? **(2 marks)**

(iii) What is the Young's modulus for the wire? **(2 marks)**

(b) In a certain day the height h of the mercury column in the barometer is 76.1 cm. What is the atmospheric pressure on such a day? The density of mercury is 13.6×10^3 kg/m^3. Show with the aid of a diagram how you obtain your solution. **(6 marks)**

(c) A metal block of mass 250 g at 130 °C is placed into 100 g copper cylinder containing 200 g of water at 20 °C. The final temperature of the system is 30 °C. The specific heat capacity of copper is 385 J/(kg.K). What is the specific heat capacity of the metal block? **(8 marks)**

QUESTION 4

(a) What is the sound level in decibels at the threshold of pain. **(2 marks)**

(b) What is the sound intensity at the threshold of pain? **(2 marks)**

(b) Light enters glass of refractive index $n_g = 1.45$ from air ($n_a = 1$) at an angle of 30° with the normal. Find the angle of refraction at the air-glass interface. **(3 marks)**

(c) The far point of a person is 100 m. What must be the focal length of the spectacle lenses for the person to see up to a distance of 5 km? **(3 marks)**

(d) A Faculty of Health Sciences student owns an electric heater rated at 1500 W and 220 V(rms).
She turns on the heater at 6:00 p.m. and switches it off at 11:00 p.m.

(i) How much current is drawn by the heater? **(2 marks)**

(ii) What is the resistance of the heater filament? **(2 marks)**

(iii) How much energy in joules is consumed by the heater during the period it is on? **(2 marks)**

(iv) How much energy in kilowatt-hours is consumed by the heater during the time it is on? **(2 marks)**

(v) If electrical energy cost 55 cents per kilowatt-hour what is the cost of the electricity consumed?. **(2 marks)**

SECTION B

ANSWER AT LEAST TWO QUESTIONS

QUESTION 5 [20 MARKS]

e) Convert the following to the SI Units indicated: [3]

i) 25 nm_____m

ii) 150 Mg_____kg

iii) 200 Cal_____kgm^2s^{-2} (where 1cal = 4.184 J)

f) Express the following in scientific notation: [2]

i) 186,000 miles s^{-1}

ii) 0.000 000 002 K

c Explain the following trends:

(iv) Atomic Radii in Angstrom units [3]

H	Li	Na	K	Rb	Cs
0.30	1.23	1.57	2.03	2.16	2.35

(v) ionisation energies in kJ/mol [3]

Na	Mg	Al	Si	P	S	Cl	Ar
496	737	577	786	1012	999	1255	1521

(vi) Pauling's Electronegativity coefficients (Unitless) [3]

Li	Be	B	C	N	O	F
1.0	1.5	2.0	2.5	3.0	3.5	4.0

d) Describe Any two ions of environmental concern. Include in your description the associated disorder and the most likely source of the ion. [6]

QUESTION 6 [20 MARKS]

a) Briefly describe the difference between an empirical formula and molecular formula. *[4]*

b) 6.853 mg of a sex hormone containing C, H and O was burned to determine its molecular formula. On burning 20.08 mg CO_2 and 5.023 mg of H_2O were obtained. The formula weight of the substance was found to be 270 g/mol.

i) Calculate the Empirical formula for the hormone [14]

ii) Calculate the molecular formula for the hormone [2]

[note that the unit 1 mg = 0.001 g = $1x10^{-3}$g]

QUESTION 7 [20 MARKS]

b) i) Define an acid solution. Give one example. [2]

ii) Name three kinds of acids found in the body. [3]

b) Briefly discuss **any one** of the following: [6]

i) Respiratory alkolosis

ii) Metabolic alkolosis

In your discussion include the cause, the symptoms and the treatment.

c) Describe the mechanism by which the body reduces acidosis. [4]

d) Calculate the concentration of a 20 g NaOH in 1 L. Refer to the periodic table to calculate the molecular weight of NaOH first. [5]

Question 8 [20 Marks]

a) Explain the difference between permanent and temporary water hardness. [6]

b) Describe three major classes of water pollution and explain how each could be removed using standard purification procedures. [10]

c) Calculate the volume of a 20% (w/v) saline solution (NaCl) that is required to prepare a 5% solution (NaCl) in a 100 ml volumetric flask. [4]

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 334 m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N m^2/kg^2
Density of mercury = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013×10^5 Pa
Gas constant $R = 8.314$ J/(K mol)
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
$I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c(*water*) = 4186 J/(kg K) c(*ice*) = 2090 J/(kg K) c(*steam*) = 2079 J/(kg K)
L_f(*ice*) = 3.33×10^5 J/kg L_v(*water*) = 2.260×10^6 J/kg

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg

THE PERIODIC TABLE OF ELEMENTS

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
Period 1	1 H 1.008																	2 He 4.003
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.9	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.01	25 Mn 54.9	26 Fe 55.85	27 Co 58.71	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.7	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 91.22	42 Mo 95.94	43 Tc 98.9	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	71 Lu 174.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 196.9	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 208.9	84 Po 210	85 At 210	86 Rn 222
7	87 Fr 223	88 Ra 226.0	103 Lr 257	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

NON-METALS

METALLOIDS

METALS

Lanthanides	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 146.9	62 Sm 150.9	63 Eu 151.3	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
Actinides	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu 239.1	95 Am 241.1	96 Cm 247.1	97 Bk 249.1	98 Cf 251.1	99 Es 254.1	100 Fm 257.1	101 Md 258.1	102 No 255

*Numbers **below** the symbol indicates the **atomic masses**; and the numbers above the symbol indicates the atomic numbers.*

Useful Relations

$(RT)_{298.15K}$=2.4789 kJ/mol

$(RT/F)_{298.15K}$=0.025 693 V

T/K: 100.15 298.15 500.15 1000.15

T/Cm^{-1}: 69.61 207.22 347.62 695.13

1mmHg=133.222 N m^{-2}

hc/k=1.438 78x10^{-2} m K

1atm	1 cal	1 eV	1cm^{-1}
=1.01325x10^{5} Nm^{-2}	=4.184 J	=1.602 189x10^{-19} J	=0.124x10^{-3} eV
=760torr		=96.485 kJ/mol	=1.9864x10^{-23}J
=1 bar		= 8065.5 cm^{-1}	

SI-units:

1 L = 1000 ml = 1000cm^3 = 1 dm^3

1 dm = 0.1 m

1 cal (thermochemical) = 4.184 J

dipole moment: 1 Debye = 3.335 64x10^{-30} C m

force: ***1N=1J m^{-1}= 1kgms^{-2}***=10^5 dyne pressure: ***1Pa=1Nm^{-2}***=1Jm^{-3}

1J = 1 Nm

power: 1W = 1J s^{-1} potential: 1V =1 J C^{-1}

magnetic flux: 1T=1Vsm^{-2}=1JCsm^{-2} current: 1A=1Cs^{-1}

Prefixes:

p	n	m	m	c	d	k	M	G
pico	nano	micro	milli	centi	deci	kilo	mega	giga
10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^{3}	10^{6}	10^{9}

General Data

speed of light	**c**	**2.997 925x10^{8} ms^{-1}**
charge of proton	*e*	1.602 19x10^{-19} C
Faraday constant	F=L*e*	9.648 46x10^{4} C mol^{-1}
Boltzmann constant	**k**	**1.380 66x10^{-23} J K^{-1}**
Gas constant	**R=Lk**	**8.314 41 J K^{-1} mol^{-1}**
		8.205 75x10^{-2} dm^3 atm K^{-1} mol^{-1}
Planck constant	**h**	**6.626 18x10^{-34} Js**
	$\hbar = \frac{h}{2\pi}$	1.054 59x10^{-34} Js
Avogadro constant	**L or N_{av}**	**6.022 14x10^{23} mol^{-1}**
Atomis mass unit	u	1.660 54x10^{-27} kg
Electron mass	**m_e**	**9.109 39x10^{-31} kg**
Proton mass	m_p	1.672 62x10^{-27} kg
Neutron mass	m_n	1.674 93x10^{-27} kg
Vacuum permittivity	$\varepsilon_o = \mu_o^{-1}c^{-2}$	8.854 188x10^{-12} J^{-1} C^2 m^{-1}
Vacuum permeability	μ_o	4πx10^{-7} Js^2C^{-2} m^{-1}
Bohr magneton	$\mu_B = e\hbar/2m_e$	9.274 02x10^{-24} JT^{-1}
Nuclear magneton	$\mu_N = e\hbar/2m_p$	5.05079x10^{-27} JT^{-1}
Gravitational constant	G	6.67259x10^{-11} Nm^2kg^{-2}
Gravitational acceleration	**g**	**9.80665 ms^{-2}**
Bohr radius	a_o	5.291 77x10^{-11} m