THE OPEN UNIVERSITY OF SRI LANKA

FOUNDATION PROGRAMME IN TECHNOLOGY - LEVEL 02

FINAL EXAMINATION 2010

CEX2312 - ENGINEERING PROPERTIES OF MATERIALS

/CEX 1330

Time allowed: 3 Hours Index Number.....

Date: 21st March 2010 Time: 9:30-12:30 hrs.

Note: The Periodic table is given on the last page for reference.

PART A:

Answer all questions.

Each question carries 3 marks and the mark for Part A makes up 30% of the total mark.

Part A should be detached from the question paper and attached to the answer script.

From question 1 to 5 select the most appropriate answer and underline.

1. A body is acted upon by a force F which varies with time t as in figure a1. Determine the graph which best represents the velocity (v) and time t variation of the body?

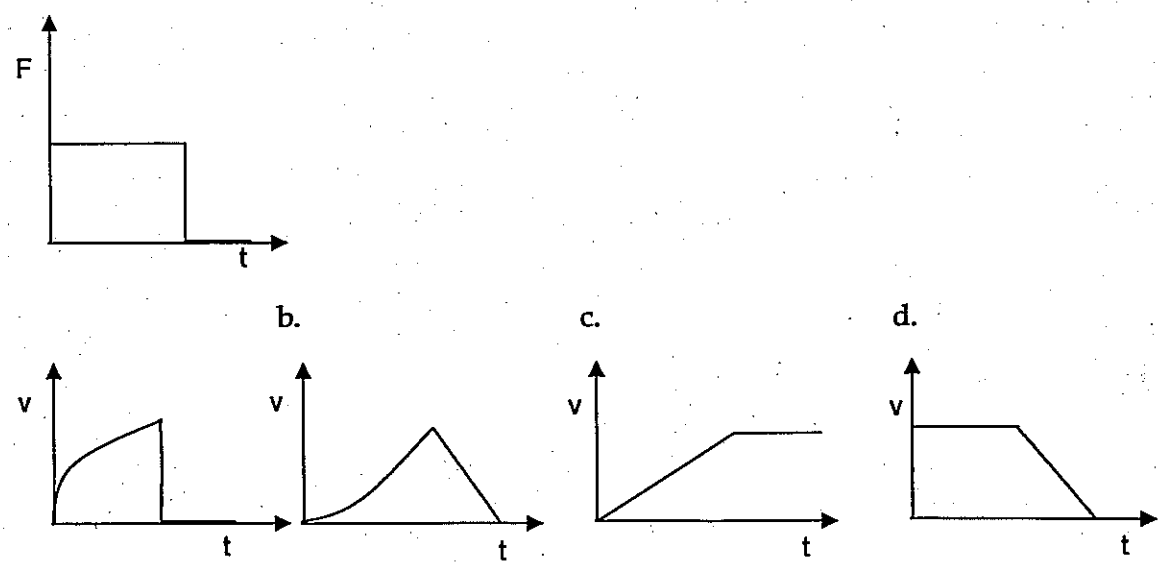

Figure a1

2. Which of the following properties of solid would change if it was transported from earth to moon?

a. mass
b. volume
c. density
d. weight

3. Which of the following atoms has the largest second ionization energy?

a. F
c. Na
b. Ne
d. Mg

4. In a simple pendulum experiment, the length l is varied and the period T is measured. To find gravitational acceleration (g) it is best to plot

a. l against T
c. $l^{\frac{1}{2}}$ against T^2
b. l *against* T^2
d. l^2 against T

5. Under ordinary room temperature conditions, the greatest number of elements are

a. gases.
c. metallic solids.
b. liquids.
d. nonmetallic plasmas.

From question 6 to 10 answers should be written in the space provided under each question.

6. Conductivity of semi conductors increases with temperature, while the good conductors decrease marginally with increase of temperature. Explain why.

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7. Describe the process of writing with chalk on a black board in terms of friction and wear.

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8. Arrange the following atoms in order of increasing atomic radius. Na, Al, P, Cl, Mg

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9. Shaking your wet hands can remove water. Explain how this happens.

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10. Arrange the following in increasing first ionization energy; F, K, P, Ca, Ne

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PART B:

Answer any 4 questions.

Each question carries 17.5 marks and the mark for part B makes up 70% of the total mark.

1.

a. The Bernoulli's equation expresses the sum of the three heads (i.e. pressure head, velocity head a

the elevation head) as $\frac{p}{\rho g} + \frac{v^2}{2g} + z = c$ and the sum takes a constant c. The terms in this equat

are p – pressure; g – acceleration due to gravity; ρ - density of water.

i. Determine the SI units for z.

ii. Express g in terms of cgs units.

iii. Derive the SI units for v.

b. The volume of a small cylindrical object can be found by taking measurements of the diamete and height h of the cylinder using a vernier caliper. The observed readings while measuring diameter and height of the cylindrical object are given in figure1b (1) and figure 1b (2) respectivel

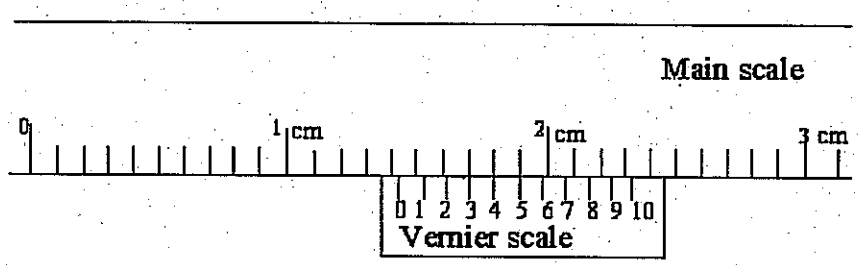

Figure 1b(1)

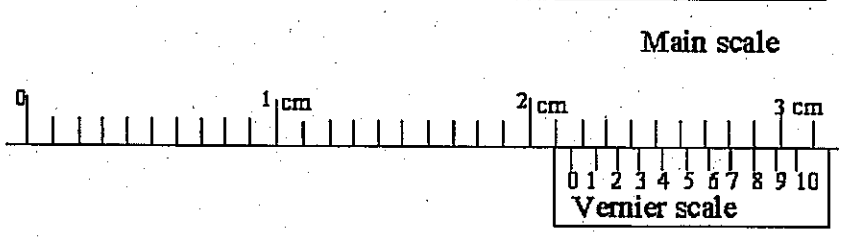

Figure 1b(2)

i. Determine the least count of the given vernier caliper.

ii. Determine the diameter of the cylindrical object.

iii. Determine the height of the cylindrical object.

iv. Calculate the volume of the cylindrical object.

v. If the cylindrical object is made of aluminium (density = 2.7g/cm^3), determine the mass of it.

c. A piece of alloy of mass 86 g suspended by a spring balance at the top is totally submerged in water. The spring balance reads 73 g when the piece of alloy is immersed in water.

i. Sketch the free body diagram for the piece of alloy indicating all the forces.

ii. Compute the up-thrust exerted by the water on the piece.

iii. Determine the volume of the piece of alloy.

iv. Compute the density of the alloy.

2.

a. In an experiment to measure the Young's Modulus for steel, a long and thin steel wire is suspended vertically and loaded at the free end. In such an experiment;

i. Explain why a long and thin wire is selected.

ii. Explain how you can measure the extension and diameter of the wire accurately.

iii. Explain the advantages that are gained by describing the elastic properties of solids in terms of stress and strain rather than force and displacement.

iv. Sketch the graph that you would expect to obtain in such an experiment showing the relation between the applied load and the extension of the wire.

v. Show how it is possible to use the graph to determine the Young modulus for the material of the wire. (State your assumptions)

vi. A uniform steel wire of length 4 m and cross sectional area of $3 \times 10^{-6}\ m^2$ is extended by 1 mm. Calculate the energy stored in the wire if the elastic limit is not exceeded. (Young's modulus of steel = 2.0×10^{11} Pa)

b. Test pieces of two metal alloys of identical size and shape were subjected to tensile strength tests up to fracture X, and the stress - strain diagrams which were obtained are shown in figure 2(b)1.

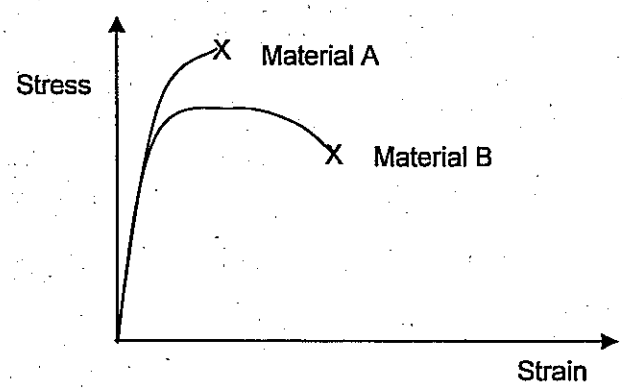

Figure 2(b)1

i. Determine which material has the greater tensile strength. Explain your answer.

ii. Find which of the two materials is more ductile. Explain your answer.

iii. Determine which material exhibits greater toughness. Explain your answer.

c.

i. List two instances where friction is made use of in everyday life.

ii. List two instances where certain measures are taken to avoid friction.

iii. Sketch a tyre of a motor vehicle that is moving forward; indicate the following forces acting on the tyre ; the weight (P), the normal reaction (R), the frictional force (F)

iv. Is the friction force acting on the tyre greater than μR or less than μR? Explain your answer.

3.

a.

i. Using appropriate diagrams, describe the way in which the movement of electrons between the atoms produces ionic bonding in potassium fluoride.

Explain why potassium fluoride;

ii. has a high melting point

iii. dissolves readily in water

iv. does not conduct electricity at room temperature

v. does conduct electricity at 800^0 C

b. From the first twenty elements of the periodic table, choose the element or elements which:

i. has the largest ionization energy

ii. forms a 1^- ion with the same electron configuration as neon.

iii. forms a 2^+ ion which is iso-electronic with argon.

iv. is a metal which forms an oxide with the formula X_2O.

v. Forms an ionic chloride with the formula XCl.

vi. Forms a giant atomic Oxide, XO_2.

vii. Forms a 2^+ ion with the electron configuration $1s^2\ 2s^2\ 2p^6$

viii. Fits the equation

$$XCl_5 \longrightarrow XCl_3 + Cl_2$$

c. Show the locations of the following, in the outline of the periodic table given in fig.3(c).

i. alkali metals

ii. alkaline earth metals

iii. halogens

iv. the noble gases

v. 2 metalloids

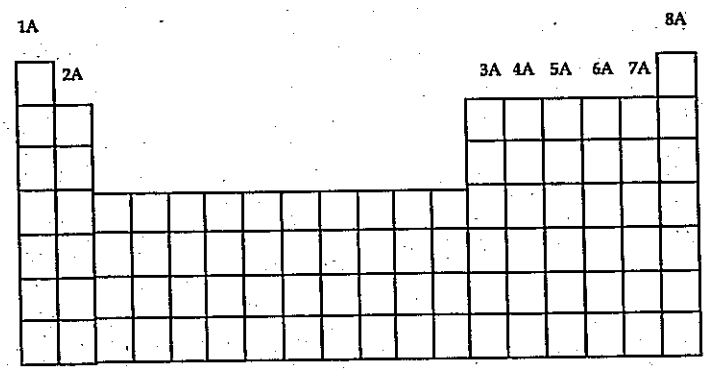

Figure 3(c)

4.

a. Table 4(a) shows some of the mechanical properties of a wide range of materials.

Material	Young Modulus 10^9 Pa	Tensile strength 10^6 Pa	Elongation %
Steel	200	250	35
Copper	120	150	45
Aluminium	70	60-120	45
Glass	71	100(about)	0 (about)
Concrete	20-40	4	
Perspex	3.4	55-70	2-10
PVC	2.5	60	2
Polystyrene	3.5	40	2.5
Nylon		70	60-300
Rubber(natural)	1 (25% elongation)	32	850

Table 4(a)

i. Aluminium and glass have almost the same values of the Young's modulus and tensile strength. Why is glass, which is much cheaper to produce, not used in place of aluminium in load bearing applications?

ii. Although concrete is used in heavy load bearing applications, the table shows a very low value of tensile strength in Concrete. How do you overcome this disadvantage? Explain your answer.

iii. Compare the stiffness between Aluminium and PVC. Explain your answer.

iv. Roughly draw stress – strain diagrams for glass and steel.

v. Explain the type of bonding present in PVC. Hence explain why it can be used as an insulator.

vi. Explain the following observation. 'Crystals of salts fracture easily, but metals are deformed under stress without fracturing'

b.

i. List three uses of plastics.

ii. Identify the properties that make plastic a suitable material for the uses selected above.

iii. What are the properties of plastics that make them a possible threat to the natural and human environment?

iv. Discuss what measures you would take to reduce the threat posed by plastics to the environment.

5.

a. Copper is a pure metal. It is the world's third most important metal, in terms of volume of consumption.

i. State the electronic configuration of copper.

ii. Describe the bonding in copper metal and hence explain why it is selected for the following applications.

A. Copper wire

B. Car radiator core

C. Electric motor windings

D. Domestic hot water cylinders

iii. Give two examples where the addition of another material improves some desirable property of copper. For each example list the material added and the property improved.

b. Silicon Carbide is a ceramic material of simple composition and structure. It is a well known abrasive material.

i. Determine the electronic configuration of Si and C.

ii. Describe its structure and bonding.

iii. Considering the bonding in Silicon carbide, explain its usage as an abrasive.

c. A good hacksaw blade costs around sixty rupees. You could also purchase a cheaper version for five rupees.

i. Explain how such blades generally fail.

ii. Compare the differences in engineering properties for the two types.

iii. List two instances in which the expensive type is preferred.

6.

a. A titration experiment was carried out by a student, to find stoichiometry of the reaction between HCl and Na_2CO_3. Titration was performed by a 2.9929 g sample of impure Sodium Carbonate dissolved in water and titrated to a methyl orange end point with 0.4150 M HCl. If 33.75 ml of the acid is used for the reaction;

i. Describe the function of an acid base indicator.

ii. Write down the equilibrium equation for the above case.

iii. Determine the percent by mass of the sodium carbonate in the sample.

iv. Consider the titration experiment that you have performed in the laboratory. What would happen and how would the results be affected by the following errors?

A. A few drops of acid are added after the indicator changes colour.

B. The acid is less concentrated than you thought.

C. You forget to add the indicator.

D. You don't swirl the flask to mix its contents thoroughly.

b. The Cathode Ray Tube led to the discovery of electrons within the atom.

i. Explain how a beam of electrons can be produced in a vacuum tube and describe an arrangement by which the beam may be deflected by a magnetic field.

ii. Millikan succeeded in measuring the electric charge of an electron using observations made on charged oil droplets. Describe the experimental set up used and the major conclusions reached by him.

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The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)