CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

General Certificate of Education Examination

JUNE 2015 **ADVANCED LEVEL**

Subject Title	ENGINEERING SCIENCE
Paper No.	2
Subject Code No.	7100

TWO AND A HALF HOURS

Answer FIVE questions only.

All questions carry equal marks.

You are reminded of the necessity for good English and orderly presentation in your answers.

All rough work should be done in your answer booklet.

You are allowed to use drawing instruments and scientific electronic calculators.

Where necessary use the following data:

Atmospheric pressure	=760 mm Hg
Acceleration due to gravity, g	$= 9.8\ m\ s^{-2}$
Elementry charge, e	1.60×10^{-19} C
Universal gas constant, R	$= 8.314\ J\ mol^{-1}\ K^{-1}$
Permeability of vacuum, μ_0	$= 4\pi x 10^{-7} H\ m^{-1}$
Permittivity of vacuum, ε	$= 8.85 \times 10^{-12}\ F\ m^{-1}$
Speed of light in vacuum, c	$= 3.00 \times 10^{8}\ ms^{-1}$.
Faraday's constant, F	$= 96500\ C\ mol^{-1}$
Avogadro's Number , N_A	$= 6.02 \times 10^{23}\ mol^{-1}$
Density of water, ρ_w	$= 1000\ kg\ m^{-3}$
Density of mercury, ρ_{Hg}	$= 13600\ kg\ m^{-3}$
Stefan-Boltzmann's constant, σ	$= 5.7 \times 10^{-8}\ W\ m^{-2}\ K^{-1}$

Relative atomic masses:

Cu = 63.6, Pb = 207.2, Cl = 35.5, O = 16; Ag = 108, Cr = 52.

1. (a) Chemical reactions produce compounds which can be classified as ionic or covalent. Give four differences between ionic and covalent compounds.

(4 marks)

(b) The standard electrode potentials for aluminium and chromium are represented as

$Al^{3+}_{(aq)}/Al_{(s)}$; $E^{\ominus} = -1.66$ V

$Cr^{3+}_{(aq)}/Cr_{(s)}$; $E^{\ominus} = -0.74$ V

(i) Define standard electrode potential. **(2 marks)**

(ii) Write a balanced redox equation to show the reaction that takes place when the two half cells are combined to form a voltaic cell. **(2 marks)**

(iii) Calculate the emf of the voltaic cell. **(1 mark)**

The two half cells are connected through an ammeter and a resistor of resistance 5 ohms, and a voltmeter is used to measure the emf generated. The circuit is allowed to run for 2 hours to deposit enough chromium.

(iv) Draw a labelled diagram of the cell and indicate all the electrical instruments mentioned above. **(4 marks)**

(v) Calculate the current flowing through the circuit. **(2 marks)**

(vi) Determine the mass of chromium and hence the number of chromium atoms deposited. **(5 marks)**

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2. (a) (i) Define Young's modulus of elasticity and give its S I unit. **(2 marks)**

(ii) The following are materials which are commonly used in some industries in Cameroon:
Copper, iron, duralumin and bronze
Which of these materials are:
- pure metals;
- alloys?

(2 marks)

(iii) Give the constituents of bronze. **(1 mark)**

(iv) You are given the following engineering materials
- Aluminium
- Silicon
- Plastic
- Pespex

Classify them in the table shown below.

Glassy	Polymer solid	Amorphous solid	Crystaline solid

(4 marks)

(b) A wire 2 m long and of cross-sectional area 10^{-6} m^2 is stretched 1.0 mm by a force of 50 N in the elastic region.

(i) Explain the term elastic region. **(2 marks)**

(ii) If the wire undergoes a stress of 5×10^{6} N m^{-1}, determine the Young's modulus for the wire.

(2 marks)

(iii) Figure 1 shows a Force versus extension plot for an engineering material.

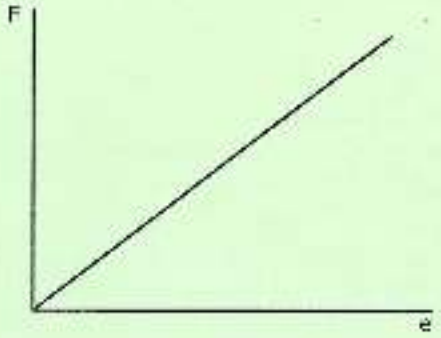

Figure 1

Derive an expression for the Young's modulus of elasticity for the material. **(2 marks)**

(c) Iron is extracted from two important ores haematite and magnetite using the blast furnace.

(i) Give the formulae of the named ores. **(2 marks)**

(ii) What method is used to extract iron from its ores. **(1 mark)**

(iii) State one function of coke during the extraction process. **(1 mark)**

(iv) Write down the equation for the conversion of the ore into the metal. **(1 mark)**

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3. (a) The motion of a car of mass 300 kg is described by the equation

$$x(t) = at^2 + b\sqrt{t}$$

where x is the displacement of the car, and a and b are constants.
After 2s, the displacement of the car was 100 m, and the velocity 20 m/s.

(i) Write expressions for the velocity and acceleration at the time t. **(2 marks)**

(ii) Determine the values of a and b, giving their units. **(3 marks)**

(iii) Calculate the driving force, and the power developed by the car at t = 5 s. **(3 marks)**

(b) A trap door of mass 15 kg and width 1.5 m hinged at A is opened by applying a force F at an angle of 45° as shown in Figure 1 below.

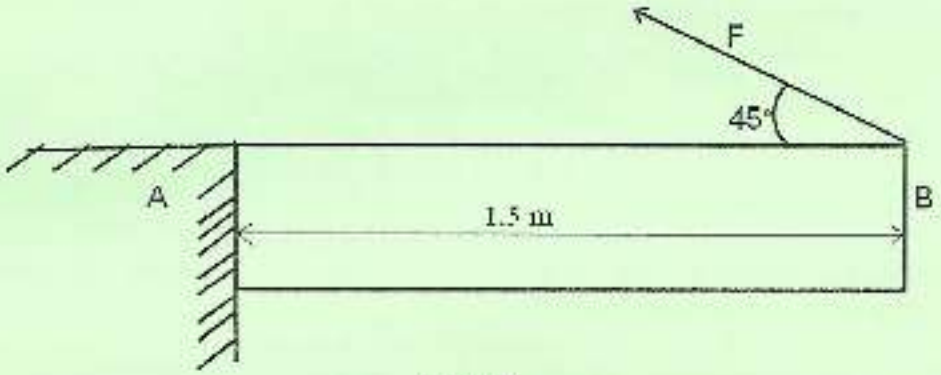

Figure 2

(i) State the conditions for the trap door to be in equilibrium. **(2 marks)**

(ii) Determine the value of the force F and the force horizontal to the hinge. **(4 marks)**

A dumb-bell consist of two spheres D and C linked to each other by a bar of length 0.6 m. The masses $M_D = 4$ g and $M_C = 4$ g are rotating about an axis through its centre of mass O. The angular velocity of the dumb-bells are $\omega_D = 0.25$ rad/s and $\omega_C = 0.25$ rad/s.

(iii) Define moment of inertia. **(1 mark)**

(iv) Determine the moment of inertia and the kinetic energy of the dumb- bell. **(4 marks)**

4. (a) (i) Identify the types of lenses shown in Figure 3 below **(2 marks)**

Figure 3

(ii) Give the characterisitics of a virtual object formed by the above class of lenses and the object is between the lens and its focus. Illustrate. **(5 marks)**

(iii) Give two advantages of optical fibres over coper cables in communication. **(2 marks)**

(b) A fish 8 cm long is 30 cm from a converging lens whose focal length is 15 cm. Find the image distance and state the nature of the image formed. **(3 marks)**

(c) A progressive wave travelling in a medium from right to left is represented by the equation $y = 0.5\sin\left(600\pi t + \frac{2\pi x}{45}\right)$ where x and y are measured in cm and t in s.

Determine

(i) The wave length and frequency of the vibration; **(4 marks)**

(ii) The maximum speed and the acceleration of the particules in the medium. **(4 marks)**

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5. (a) (i) State the law of floatation. **(2 marks)**

(ii) The volume of liquid passing per second through a pipe when the flow is steady depends on three factors. Name them. **(3 marks)**

(iii) Explain how an aircraft's wing produces a lift for the aeroplane. **(2 marks)**

(b) The volume flow rate of a liquid through a pipe of cross-sectional area A and length l is given by

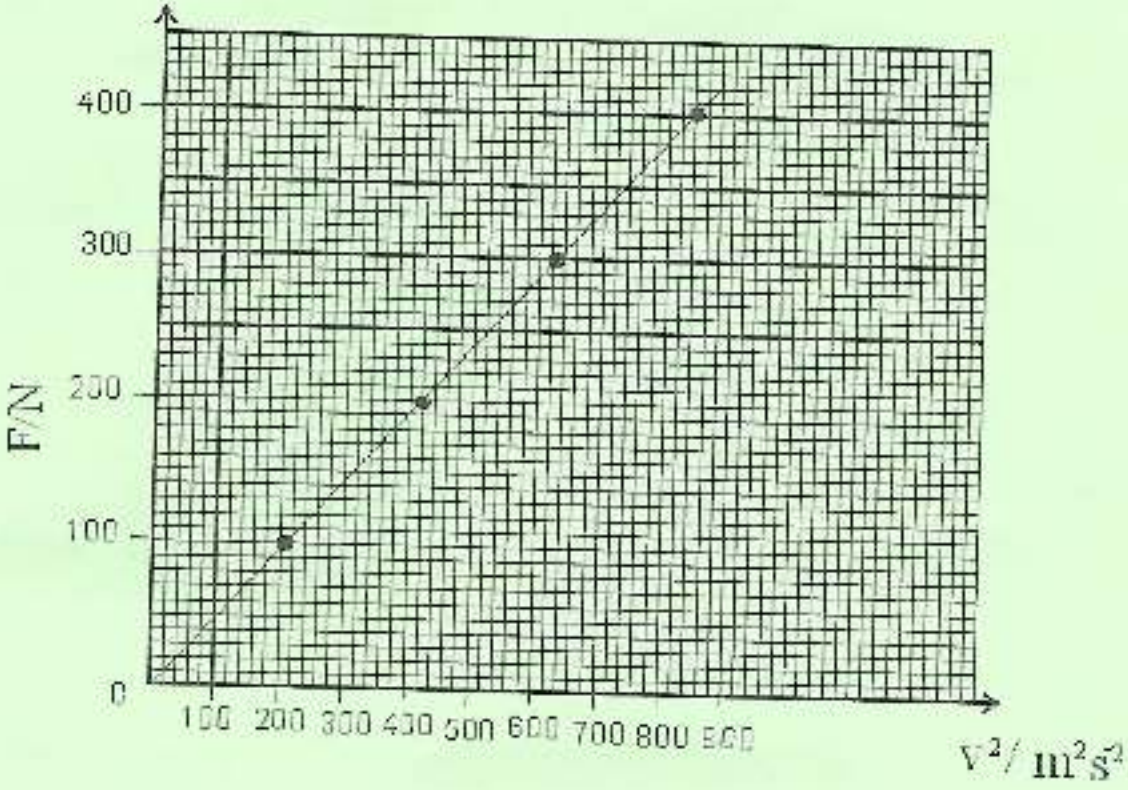
$\frac{v}{t} = \frac{CA^2\Delta p}{\eta l}$ where Δp = pressure different; η = viscosity of the liquid.

In one case a needle 0.035 m long of internal cross- sectional area 3.0×10 m^2 is used.
The required volume flow rate into a patient is 2.5×10^{-7} m^{3}s^{-1}.
The magnitude of $\eta = 4.0 \times 10^{-3}$ Pa.s.
The value of C = 0.046.
Use the equation given above to determine the pressure difference between the ends of the needle that will produce the required flow rate. **(4 marks)**

(c) The drag force on a car is caused by the air flow around the car and is related to the speed V of the car by the equation.

$F_B = KA\rho V^2$, where

A = front cross-sectional area of the car;
ρ = density of air;
K = is a constant.



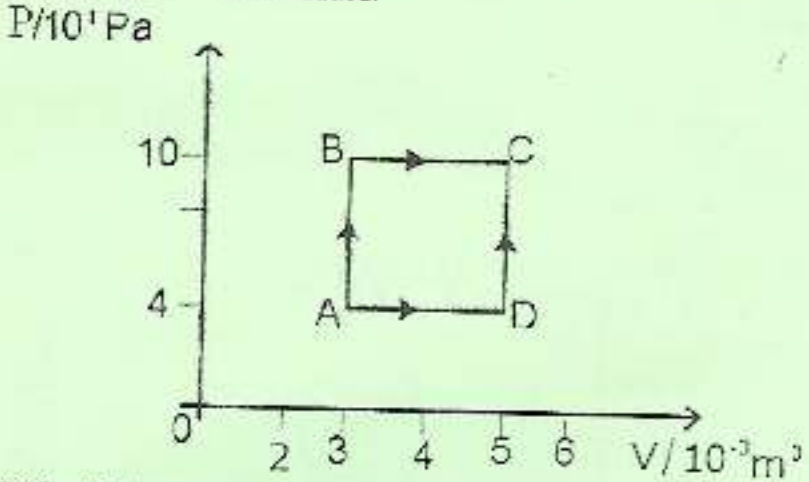
How does the drag force on the car vary with the square of the speed? **(2 marks)**

From the graph, determine

(i) The drag force on the car when its speed is 20 ms^{-1}; **(2 marks)**

(ii) The value of K. **(5 marks)**

6. (a) In Figure 5 below, BC and AD represent isobaric processes while AB and DC represent isovolumetric processes . In the process AB, 300 J of heat is added to the system while in the process BC, 800 J of heat is added.



(i) Define the terms:
- Isobaric process;
- Isovolumetric process. **(4 marks)**

Using the first law of thermodynamics,

(ii) calculate the internal energy change in the processes AB and AD. **(5 marks)**

(b) A fixed mass of gas of volume $2 \times 10^{-3} m^3$ and temperature 18°C has a pressure of 3×10^5 Pa. When heated to a temperature of 300°C, the pressure increases to maintain a constant volume. Determine:

(i) The new pressure ; **(1 mark)**

(ii) The density of the gas and its mass at 18°C, if the molar mass of the gas is 44 g mol^{-1}. **(2 marks)**

(c) The Figures 2a and figure 2b represent system A and system B.

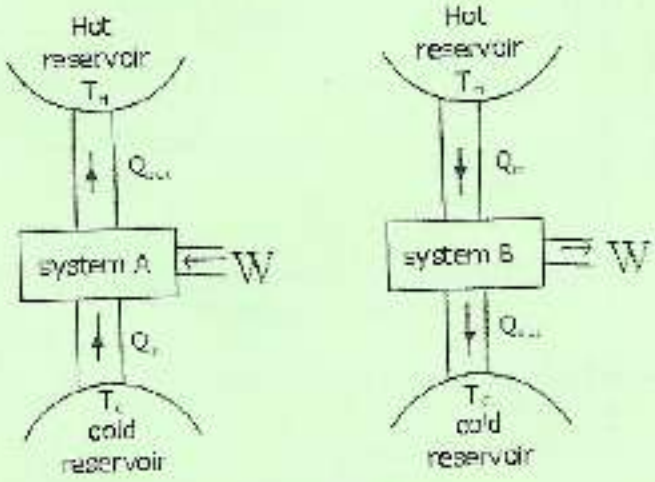


Figure 6

(i) Name the systems A and B. **(2 marks)**

(ii) Write the equation for the work done in system A and system B. **(2 marks)**

(iii) In system A, 3×10^5 J of work is supplied into the system and 5×10^5 J of heat is taken from the cold reservoir and an amount of heat Q is delivered into the hot reservoir.

(a) Determine the value of the energy flow out of the cold reservoir Q and name the physical law applied to it. **(2 marks)**

(b) Justify why an energy source is needed to supply external energy as work to extract energy from a cold reservoir to a hot reservoir. **(1 mark)**

(c) Calculate the coefficient of performance of system A. **(1 mark)**

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7. (a) Define the following:

(i) Electric potential;

(ii) Temperature coefficient of resistance;

(iii) Capacitance of a capacitor. **(6 marks)**

(b)

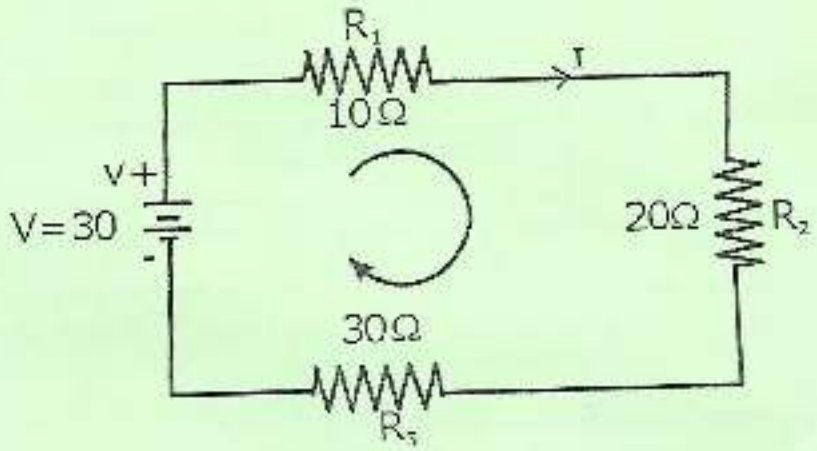

Figure 7

Using the indicated direction of flow on the circuit.

(i) Write a loop equation for the circuit shown above and determine I. **(3 marks)**

(ii) **(2 marks)**

(c) Figure 8 below shows a basic amplifier circuit with an n – p – n transitor.

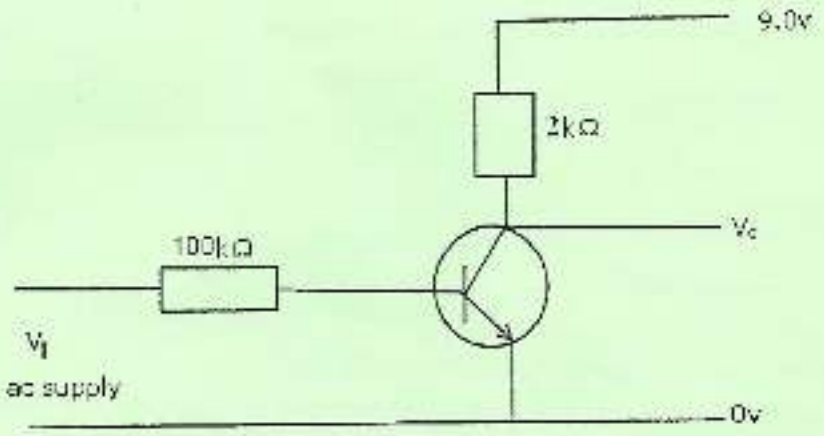

Figure 8

If the voltage V_i is 4.0 V, and the ac and dc gain for the transistor is 75, calculate

(i) The base current;
(ii) The collector current;
(iii) The output voltage.

(6 marks)

(d) Calculate the resistance of a copper trace on printed circuit board if the trace is 10 cm long, 0.005 cm thick and 0.2 cm wide.
(Resistivity of copper = 1.7×10^{6} Ω cm)

(2 marks)