ADVANCED LEVEL NATIONAL EXAMINATIONS, 2019

SUBJECT: PHYSICS

PAPER II: THEORY

COMBINATIONS:

- **PHYSICS-CHEMISTRY-BIOLOGY (PCB)**
- **PHYSICS-CHEMISTRY-MATHEMATICS (PCM)**
- **MATHEMATICS-PHYSICS-GEOGRAPHY (MPG)**
- **MATHEMATICS-PHYSICS-COMPUTER SCIENCE (MPC)**

DURATION: 3 HOURS

INSTRUCTIONS:

1) Write your names and index number on the answer booklet as written on your registration form and **DO NOT** write your names and index number on additional answer sheets of paper if provided.

2) Do not open this question paper until you are told to do so.

3) This paper consists of two sections: **A** and **B**.

    SECTION A: Attempt **ALL** questions.   **(55 marks)**

    SECTION B: Attempt only **THREE** questions.   **(45 marks)**

4) You may use a non-programmable calculator and a mathematical set.

5) Use only a **blue** or **black** pen for answering and a **pencil** for drawing.

    Useful constants
    The mass of electron $m_e = 9.11 \times 10^{-31}$ kg
    Planck's constant $h = 6.626 \times 10^{-34}$ J.s
    Speed of light in vacuum $C = 3 \times 10^8 m/s$
    Electron charge $e = 1.6 \times 10^{-19} C$
    Acceleration due to gravity $g = 9.81 \ m/s^2$

SECTION A: ATTEMPT ALL QUESTIONS (55 marks)

1) Use **True** or **False** to answer the sub questions below.

   a) The thermodynamic process in which the temperature remains
      constant is adiabatic. **(1mark)**

   b) The device illustrated in the diagram below (figure 1) is

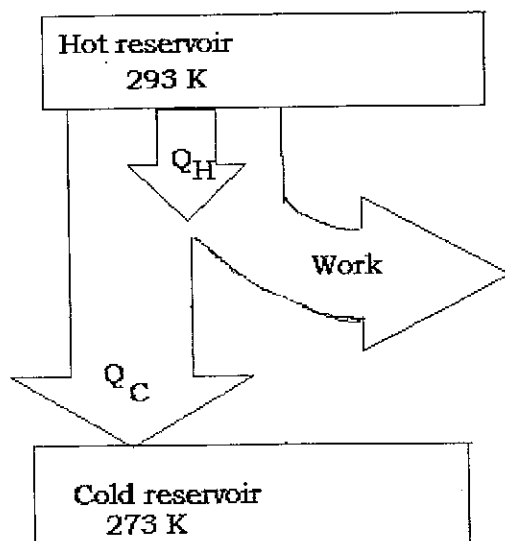   a heat engine. **(1mark)**

Figure 1

   c) The efficiency of the engine device illustrated above is 20%. **(1mark)**

2) A ball of mass **m** attached to a string is moving anticlockwise (in a

   direction opposite to the direction in which the hands of a clock move)

   in a vertical circle of radius **r**, with a constant speed **v**.

   Assume that at time **t'**, the string is cut exactly at the point where

   the ball is at the top of its motion (the top of the circle).

   a) Draw a diagram to better visualize the motion of the ball
      immediately after the string is cut. **(1mark)**

   b) Why does the ball follow the direction shown in the diagram? **(1mark)**

   c) What is the expression of the ball's acceleration at time **t'**? **(1 mark)**

3) Why are applications of physics very important to Agriculture? **(3 marks)**

4) a) Describe energy degradation/dilapidation which occurs when

   a 60 W electric light bulb is in use. **(2 marks)**

   b) How does a hydroelectric power work? **(2 marks)**

5) a) What do you understand by the following terms used when

   describing LASER?

       i) Stimulated emission of radiation. **(1mark)**
       ii) Population inversion. **(1mark)**

   b) Explain why LASER is considered as highly monochromatic and
   coherent source of light. **(2 marks)**

6) A terrestrial telescope is formed by three convex lenses namely:

   objective L_1 erecting lens L_2 and an eyepiece L_3.

   The focal lengths of these lenses are f_1, f_2 and f_3 respectively.

   The rays of light from an object at infinity are oblique to the common

   principal axis. L_1 forms from an object at infinity, an intermediate

   image I_1 .

   This is at a distance $2f_2$ in front of L_2. The image I_2 given by L_2

   from I_1 acts as the object for the eyepiece in the usual way.

   The eyepiece forms a final image at infinity.

   a) Use a ray diagram to find the final image given by the terrestrial
     telescope described above. **(3 marks)**

   b) According to the above functioning of terrestrial telescope , what

   is the disadvantage of this arrangement of lenses ? **(1mark)**

7) a) Show that baryon number is conserved or not in the following

   reaction of a pion with a proton: $\pi^+ + p \rightarrow K^+ + \Sigma^+$ **(1mark)**

   b) The charges of up, down and strange quarks are

   $$up = +\frac{2}{3}e, \quad down = -\frac{1}{3}e \quad \text{and} \quad strange = -\frac{1}{3}e \text{ respectively where e}$$

   is the absolute value of the electron's charge.

   How many quarks make up a proton? Justify your answer. **(2 marks)**

8) a) The mean distance of the Earth from the sun is 149.6 x10⁶ km

and the mean distance of Mercury from the Sun is 57.9 x10⁶ km.

The period of Earth's revolution is 1 year.

Prove that the period of Mercury's revolution is 0.24 years. **(2 marks)**

b) Suppose that the gravitational force between two massive

spheres is 100N. If the distance between the spheres is doubled,

what will be the force between the masses? Explain your answer. **(2 marks)**

9) a) (i) Provide any one type of optical fibres. **(1mark)**

(ii) What causes optical signal attenuation during the signal

propagation through optical fibres ? **(1mark)**

b) Explain how the light is guided through the core in the structure

of optical fibres. **(2 marks)**

10) a) What do you understand by the term forced oscillations?

You may explain this term in terms of the applied forces and

energy transfer. **(1 mark)**
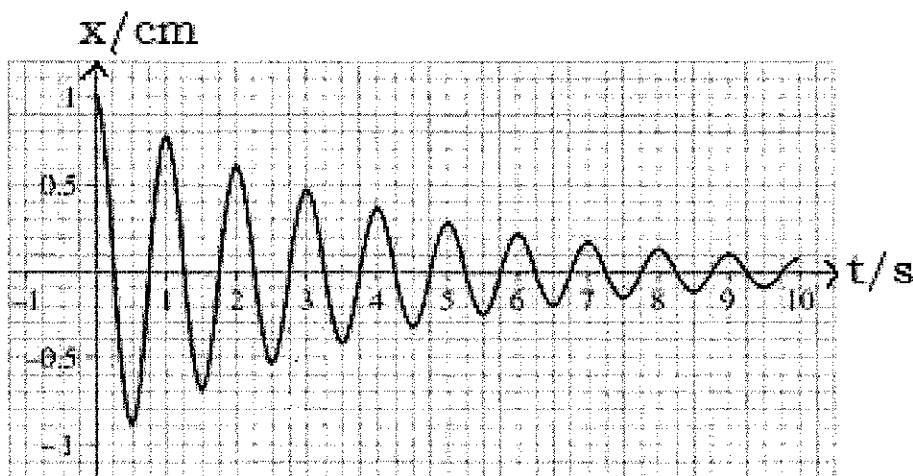
b) Interpret the following diagram (figure 2)

Figure 2 **(2 marks)**

11) A frequency of 2.4 x 10¹⁵ Hz is used on magnesium with work
function of 3.7 eV .

a) What is the energy transferred by each photon in eV ? **(2 marks)**

b) Show that the photoelectric effect will occur or not. **(2marks)**

12) a) Loudness and pitch are some characteristics of a musical note. Specify the physical property of a sound wave on which each characteristics provided depends. **(2 marks)**

b) A particular organ pipe has a length of 72 cm, and it is open at both ends. Assume that the speed of sound in air is 340 m/s:

    (i) Find the wavelength of the fundamental stationary waves in this pipe. **(1 mark)**

    (ii) What is the corresponding fundamental frequency? **(2 marks)**

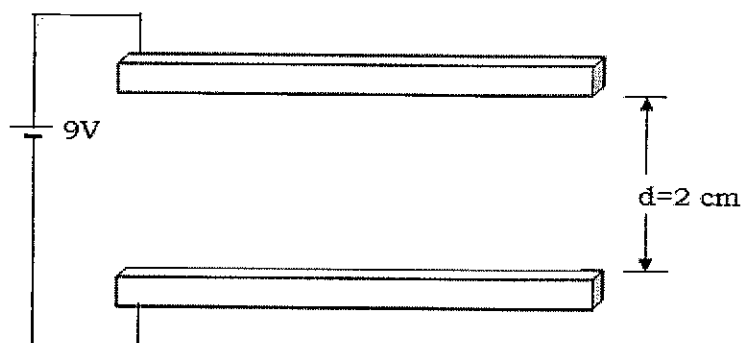13) An electric field is created in a region of space between two metal plates as shown below (figure 3)

Figure 3

a) Copy the diagram and draw the electric field lines of force between the plates. **(1 mark)**

b) How do you know if the electric field created between the plates above is uniform or not ? **(1mark)**

c) Determine the magnitude of the electric field created between the plates. **(2 marks)**

14) Show that:

a) The Broglie wavelength associated with an electron moving at 5.31×10^6 m/s is $\lambda = 1.37 \times 10^{-10}$ m **(2 marks)**

b) The momentum of a photon which has a wavelength of 400 nm is $P = 1.657 \times 10^{-27}$ kgm/s **(1 mark)**

15) Analyze the following electrical circuit (figure 4)

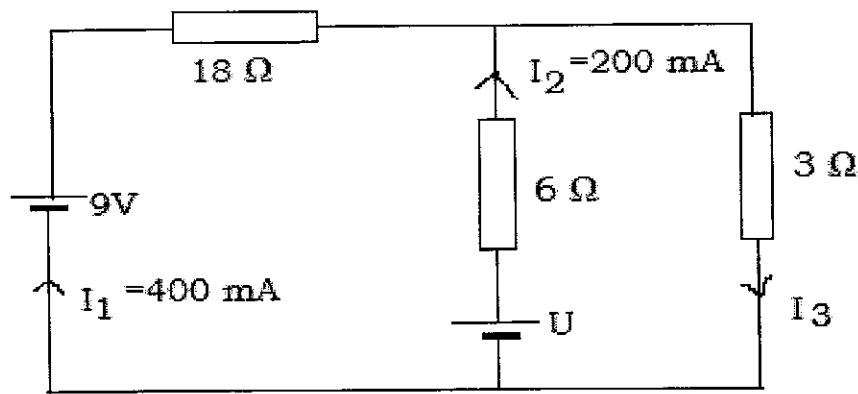*Figure 4*

Apply Kirchhoff's laws to find:

a) The current I_3 **(2 marks)**

b) The potential difference U   **(2marks)**

SECTION B: ATTEMPT ONLY THREE QUESTIONS (45 marks)

16) In January 2018, Rwanda Utilities Regulatory Authority (RURA) wrote a document entitled 'Managing the change from analog to terrestrial digital broadcast in Rwanda'.

Briefly, this document was meant to provide a basis for the migration process from analog to digital broadcasting in Rwanda. Discuss the benefits to Rwanda for shifting from the analog system of communication to digital system of communication.   **(15 marks)**

17) a) Considering that the Earth has always warmed and cooled naturally, people believe that human actions are mainly responsible for present day accelerated global warming. Evaluate the validity of this statement.   **(10 marks)**

b) Predict the impact of global warming on the environment and on life in general.   **(5 marks)**

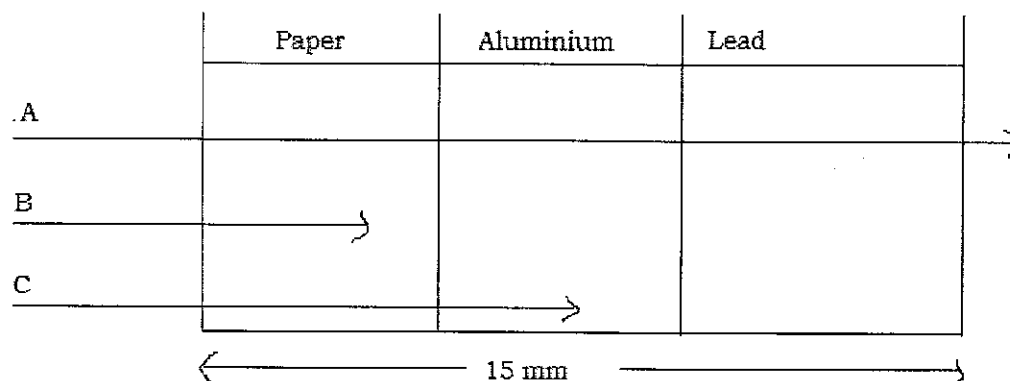18) a) The following arrows (figure 5) show how far different types of nuclear radiations penetrate different materials.

	Paper	Aluminium	Lead	
A				→
B	→			
C		→		

← 15 mm →

Figure 5

Identify the radiations A, B and C   **(3 marks)**

b) The table below describes the nuclei of four atoms

uranium-234	radon-220	plutonium -238	americium-238
$^{234}_{92}U$	$^{220}_{86}Rn$	$^{238}_{94}Pu$	$^{238}_{95}Am$

(i) All nuclei are unstable and have a different **half-life** between each other.

Explain the term **"half-life"**.   **(1 mark)**

(ii) The graph below (figure 6) shows how the activity in becquerel (Bq) of a sample of radon -220 changes with time in seconds.
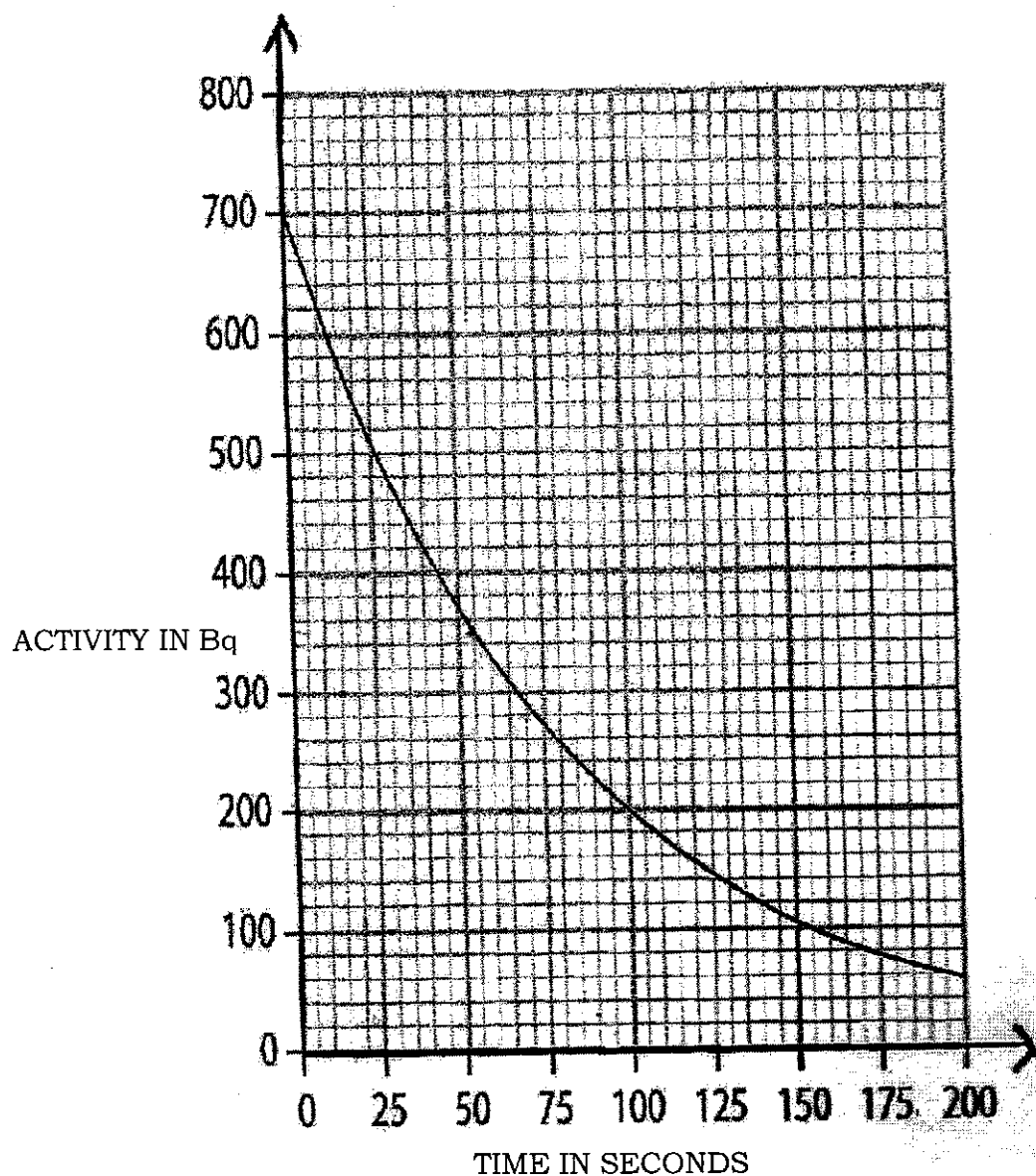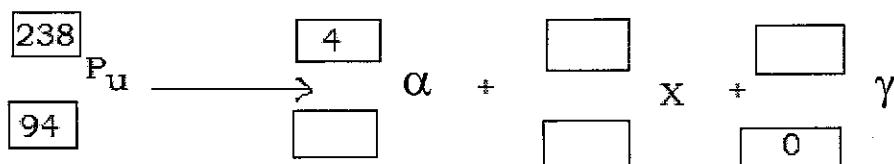
Figure 6

Use the graph to find the half life of radon-220 **(2 marks)**

c) When plutonium-238 decays, it emits an alpha particle

a gamma particle

i) Complete the decay equation below for plutonium -238

$$^{238}_{94}P_u \longrightarrow {^4_\square}\alpha + {^\square_\square}X + {^\square_0}\gamma$$

(4 marks)

ii) Identify the element X **(1 mark)**

d) The mass of proton m_p is 1.007825 a.m.u and the mass of a neutron m_n is equal to 1.008665 a.m.u. The mass of $^{14}_{6}C$ is 14.003242 a.m.u and 1uma= 931.5 MeV.

Find the:

(i) mass defect of $^{14}_{6}C$ **(2marks)**

(ii) The binding energy of $^{14}_{6}C$ **(1 mark)**

(iii) The binding energy per nucleon of $^{14}_{6}C$ **(1 mark)**

19) Study the following Hertzsprung-Russell (HR) Diagrams (figure 7 and figure 8) and answer the questions that follow:
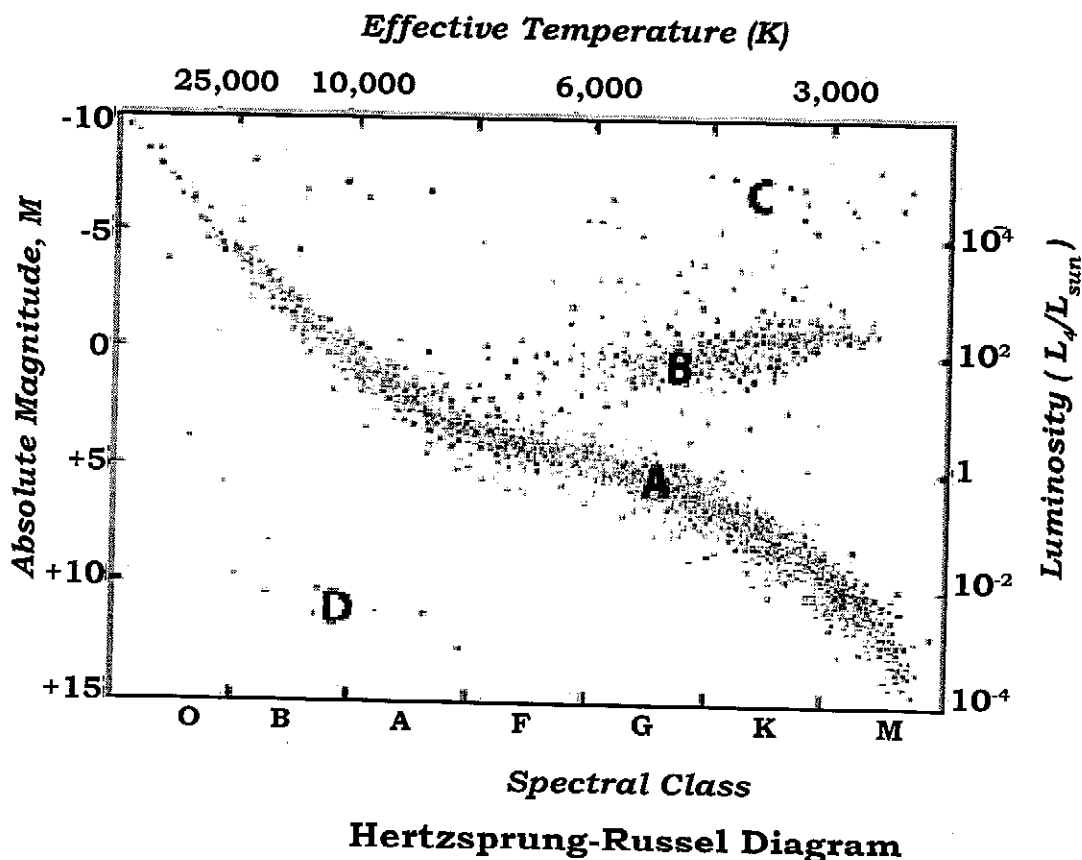

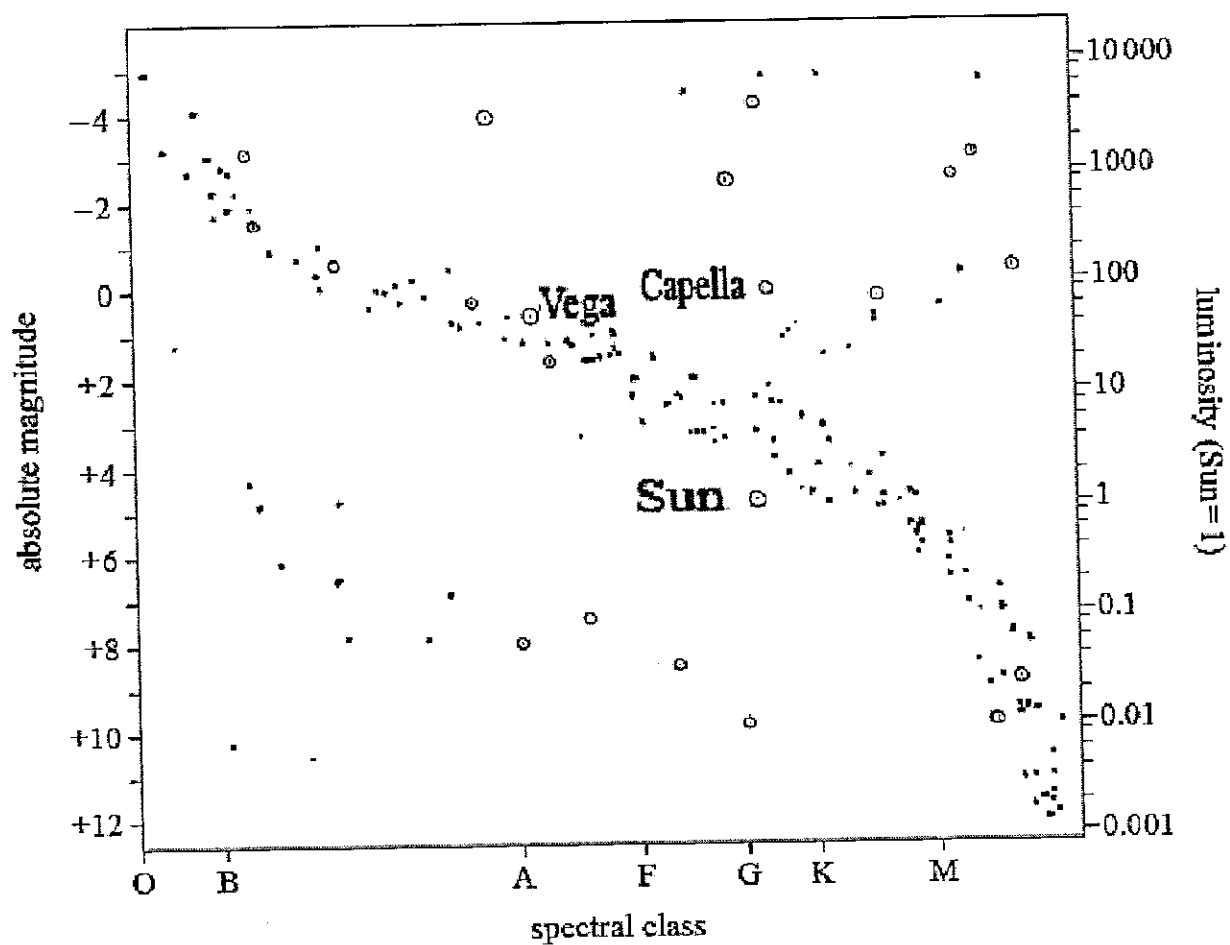**Hertzsprung-Russel Diagram**

Figure 7

Figure 8

a) Using the HR diagram (figure 7) given above, indicate a letter

(A, B, C or D) which represents each of the following regions:

    i) main sequence stars   **(1mark)**

    ii) white dwarfs   **(1mark)**

    iii) Red giants   **(1mark)**

    iv) Red super giants   **(1mark)**

b) What do you understand by the following terms which are indicated

  on both HR diagrams?

    i) Luminosity of a star.   **(1 mark)**

    ii) Absolute magnitude of a star.   **(1 mark)**

c) What two factors affect a star's luminosity as indicated

   on HR diagrams? **(2 marks)**

d) Using data from both HR diagrams:

   i) Identify the spectral class of the sun. **(1mark)**

   ii) Provide one example of a main sequence star. **(1mark)**

   iii) Estimate the luminosity of Capella in terms of that of
      the Sun. Note that $L_{sun}=1$ **(1 mark)**

   iv) Why does Capella have a greater surface area than
      the Sun? **(1 mark)**

   v) Estimate the surface temperature of the star called Vega. **(1mark)**

   vi) The intrinsic luminosity of the Sun is equal

      to $L_s=3.83 \times 10^{26}$ W. What is the luminosity of Vega in W? **(2 marks)**

20) a) Identify and explain the types of static equilibrium **(6 marks)**

   b) A bar 1m long has five forces acting on it as shown in the following
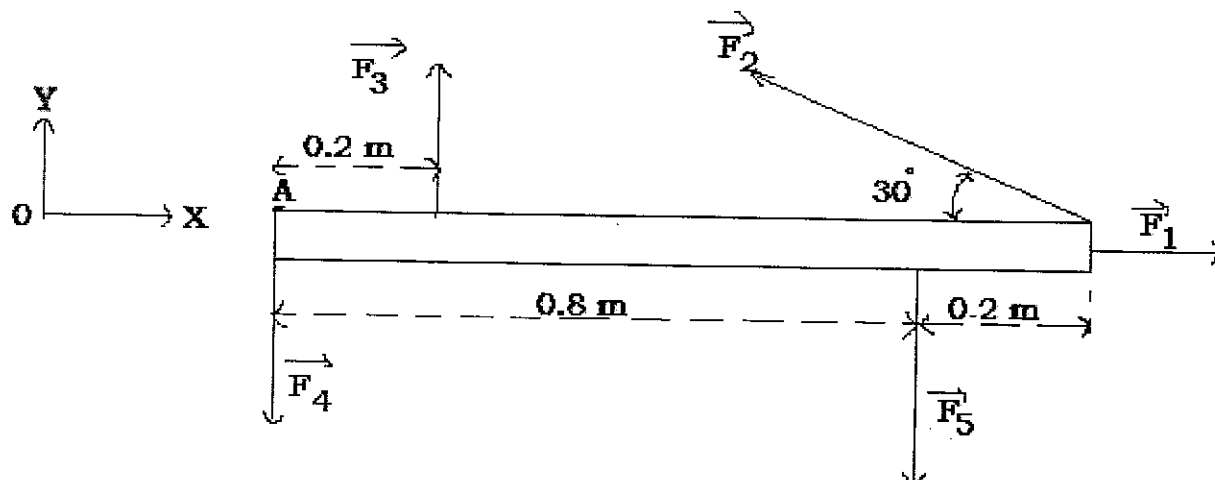   diagram (figure 10)drawn not to scale

Figure 9

The magnitudes of the 5 forces are $F_1=4N$, $F_2=8N$, $F_3=5N$, $F_4=6$ N, $F_5=7N$

   i) What are the conditions required for static equilibrium
     to occur? **(2 marks)**

ii) What is the magnitude and location of the single force
required to produce static equilibrium of the bar?
Take **A** as a reference point
(3 marks)

iii) The weight and thickness of the bar are insignificant

Hint: Follow these steps to answer this question
Find the sum of the components of all forces along x-axis
Find the sum of the components of all forces along y-axis
Find the components F'_x and F'_y of the force $\vec{F'}$

required to produce static equilibrium.
Find the sum of components of the torques of forces
along x-axis and y-axis with respect to the point A
(4 marks)