



# KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

## FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

### SPH 351: PHYSICS OF ENERGY AND ENVIRONMENT

**DATE: TUESDAY, 29<sup>TH</sup> NOVEMBER 2011**

**TIME: 2.00 P.M. – 4.00 P.M.**

#### **Instructions:**

This examination paper contains five questions. Question one carries 30 Marks and the rest carry 20 Marks each.

Answer Question one and any other two questions.

#### **Useful Information:**

Wien's constant  $B \simeq 2.90 \times 10^{-3} \text{ mK}$

radius of the earth  $R_e \simeq 6.37 \times 10^3 \text{ km}$

radius of the earth's moon  $R_m \simeq 1.74 \times 10^3 \text{ km}$

radius of the sun  $R_s \simeq 6.95 \times 10^5 \text{ km}$

distance between the earth and it's moon  $d_{e-m} \simeq 3.84 \times 10^5 \text{ km}$

mass of the earth  $M_e \simeq 5.98 \times 10^{24} \text{ kg}$

mass of the moon  $M_m \simeq 7.35 \times 10^{22} \text{ kg}$

gravitational constant  $G \simeq 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$

solar constant  $F_s \simeq 1400 \text{ W/m}^2$

Stefan - Boltzmann's constant  $\sigma \simeq 5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$

Avogadro's number  $N_A \simeq 6.023 \times 10^{23} \text{ Atoms/mole}$

electron volt  $1\text{eV} \simeq 1.602 \times 10^{-19} \text{ J}$

1 calorie  $\simeq 4.184 \text{ Joules}$

air density  $\simeq 1.3 \text{ kg/m}^3$

specific heat capacity of air  $\simeq 1000 \text{ J/kg/K}$

---

**Question 1:**

(a) An automotive engine developer proposes hydrogen as fuel for a new engine. The engine is designed to have a maximum of 65% fuel efficiency. The production of hydrogen fuel and electrolysis is at an efficiency of 19.5%. Calculate the total efficiency for the new engine and compare with a typical total efficiency value of  $\simeq 20\%$  for engines available in the market.

(5 Marks)

(b) Calculate the quantity of heat required to raise the temperature of air by  $10^{\circ}\text{C}$  in a  $3\text{m} \times 3\text{m} \times 3\text{m}$  room

(5 Marks)

(c) Briefly describe the generation of hydroelectric power. Your explanation should include a sketch and the main physics concepts.

(5 Marks)

(d) Sketch a typical I-V characteristic curve for a solar cell. Hence explain how to calculate the conversion efficiency of a solar cell.

(5 Marks)

(e) A 15m diameter windmill delivers about 42kW power when operating at an average windspeed of 10m/s. Calculate the efficiency of the windmill.

(5 Marks)

(f) Briefly explain the term nuclear fission. Calculate the energy released in the fission of 10g of uranium 234. Assume energy released per fission is 150 MeV.

(5 Marks)

**Question 2:**

(a) Briefly explain the black body spectrum. Include a sketch in your explanation. Estimate the quantity of heat radiated by a human being,  $T \simeq 310\text{K}$ .

(10 Marks)

(b) Briefly describe the geological conditions for oil reserves. Your explanation should include a sketch of a typical geological structure for oil deposits.

(10 Marks)

**Question 3:**

(a) Briefly describe the energy production in hydrocarbon reactions, for example methane. Consider an engine running on pure octane. Write the chemical reaction for the process of burning octane, hence calculate the maximum amount of energy produced and also the maximum amount of CO<sub>2</sub> emitted when 1kg of octane is fully burnt by the engine. State any assumptions made.

(10 Marks)

(b) Use a suitable diagram and briefly explain the flow of heat energy in determination of the efficiency of a heat engine. Explain why the efficiency of a heat engine can never be equal to unity. Hence calculate the efficiency of an engine that delivers heat energy at 400<sup>0</sup> K to the ambient air at 293<sup>0</sup> K.

(10 Marks)

**Question 4:**

(a) Briefly explain the use of photovoltaics in electricity generation. Your explanation should include the following,

- (i) a sketch of a photovoltaic cell,
- (ii) generation of electric current,
- (iii) types of photovoltaic cells,
- (iv) typical efficiency values, and,
- (v) main disadvantages of photovoltaic technology.

(10 Marks)

(b) Briefly explain the term activation energy as applied to nuclear fission process. Illustrate your explanation using a sketch of the nuclear potential at various stages of nuclear fission process. Write the equation for neutron-induced fission of uranium 235.

(10 Marks)

**Question 5:**

(a) Briefly explain the harnessing of solar energy. Your explanation should include the following,

- (i) the energy production process(es) in the Sun,
- (ii) the solar energy spectrum,
- (iii) the solar energy balance in the earth's atmosphere, and,
- (iv) typical considerations in the calculation of efficiency of a flat plate collector.

(10 Marks)

(b) Briefly explain the great energy disparity in the world. Include a sketch of GDP/capita versus oil production/capita.

(10 Marks)

\*\*\*\*\*