

UNIVERSITY OF ESWATINI
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF PHYSICS

MAIN EXAMINATION, DECEMBER 2019

TITLE OF PAPER : ENERGY AND ENVIRONMENTAL PHYSICS

COURSE NUMBER : PHY 635

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : Answer FOUR (4) questions only.

: Each question carries 25 Marks

: Marks for different sections are shown
in far right margin.

THIS PAPER HAS 3 PAGES, INCLUDING THIS ONE.

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THE INVIGILATOR.

1. (a) State the composition of the Earth's atmosphere. [4]
- (b) With the aid of a diagram, describe the vertical structure of the standard atmosphere. [8]
- (c) What is the Zero Dimensional Energy Balance Model and how does its prediction for the Earth's radiative equilibrium temperature compare with the observed value? [4]
- (d) The temperature T of a black body can be related to the wavelength of peak emission λ_{peak} using Wien's law:

$$T\lambda_{peak} = 2.898 \times 10^{-3} mK$$

- i. Find the emission temperature T_{sun} of the sun using an estimate of the peak wavelength of solar radiation. [4]
- ii. Estimate the emission temperature of the earth T_E , and use Wien's law to find λ_{peak} of radiation emitted by the earth. In what part of the spectrum does this lie? [5]

2. (a) With examples, explain what fossil fuels are. [2]
- (b) Differentiate between aerobic and anaerobic decompositions. [2]
- (c) Define EROI and state its importance in oil exploration. [2]
- (d) Mention three types of coal. [3]
- (e) Define the following terms regarding coal mining techniques
 - i. Strip mining, [2]
 - ii. Subsurface mining, [2]
 - iii. Mountaintop removal. [2]
- (f) Give two ways in which natural gas is formed. [2]
- (g) What is *fugitive emission* and how is it controlled in oil exploration? [2]
- (h) Name three alternative fossil fuels. [3]
- (i) State the major downsides of the alternative fossil fuels mentioned above. [3]

3. (a) What is energy efficiency? [2]
- (b) An electric motor consumes 100 watts (W) of electricity to obtain 90 W of mechanical power. Determine its energy efficiency η_E . [4]
- (c) State the relevance of energy efficiency for large-scale renewable energy? [4]
- (d) A steam power plant operates in a cycle with the boiler at $T_1 = 340^\circ C$ and the condenser at $T_2 = 25^\circ C$. Calculate the maximum efficiency allowed by the 2nd Law of Thermodynamics. [5]
- (e) What is the greenhouse effect? [3]
- (f) What are the major greenhouse gases present in Earth's atmosphere and which of these gases has the dominant contribution to the greenhouse effect? [3]

- (g) Explain the terms “radiative forcing”, in the context of global warming. [4]
4. (a) State the main sources of water pollution. [4]
(b) Describe the control measures of water pollution. [5]
(c) Explain how the Kingdom of Eswatini can control the sources of air pollution. [7]
(d) What are the sources of soil pollution? [3]
(e) Name three types of ionising radiation and explain its effects on human health. [6]
5. (a) Explain briefly how a solar cell generates electricity. [5]
(b) Using a suitable sketched diagram, define the following terms regarding solar cells [10]
 - Short circuit current, I_{sc} ,
 - Open circuit voltage, V_{oc} ,
 - Fill factor, FF ,
 - maximum power, P_{max} .
- (c) Write the equation for the efficiency of a solar cell. [1]
(d) What area of solar panels would be needed in space to produce the same amount of power as Maguga dam power station (20MW) if the panels are 5% efficient? [2]
(e) State the pros and cons of solar cells. [7]

END