

SPRING EXAMINATION 1998-99

EP327: PHYSICS OF THE ENVIRONMENT

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Time allowed : THREE hours.

Answer FIVE questions.

- Q.1 (a) Write down the equation of continuity. Define each term in the equation and explain the significance of the equation.
- (b) Bernoulli's equation is $P + \frac{1}{2} \rho v^2 + \rho gh = \text{constant}$ along a _____. What is the missing term? Explain what each term in the equation represents and give a qualitative justification for the equation.
- (c) Describe how the above two equations can be used to explain the flight of an aeroplane.
- (d) What is ram pressure and how could you determine the air speed of a plane?
- Q.2 (a) Explain what is meant by a heat engine and what the second law of thermodynamics is in relation to heat engines.
- (b) What is the maximum efficiency of a heat engine? Relate this to the conversion of fossil fuel energy into electricity.
- (c) Describe the ideal petrol engine cycle and the term engine knock. How can engine knock be eliminated? What effect does engine knock have on the efficiency of petrol engines? Explain.
- Q.3 (a) Give a brief description of biomass as a renewable energy resource and state its advantages in comparison with fossil fuels and other solar energy conversion techniques. Give an example of an electricity generating plant which is based on biomass.
- (b) Biomass depends on photosynthesis. Outline the basic chemical reaction involved. Calculate the radiant energy ΔH required to fix 1 mole of carbon: ΔH (Kj mol⁻¹) (the enthalpy of formation) is 0 for O₂, -285.8 for H₂O, -393.5 for CO₂, and -209.3 for CH₂O. Assuming that the combustion proceeds at 100% efficiency how much energy is produced in eV per C atom, and in MJ/kg of carbohydrate material [CH₂O]?

Q4:(a) The heat of combustion of natural gas is 55 GJ per tonne. Work out the amount of energy released per kilogram of CO₂ produced. The average person uses about 1300 kWh of energy a year for hot water, estimate the contribution of CO₂ due to this if:

1. A gas burner with 90% efficiency is used.
2. Electrically powered heaters are used.

(b) Pentane (C₅H₁₂) has a heat of combustion of 48 MJ/kg. Calculate the CO₂ emissions if we burn 1 kg of pentane. If we run a petrol engine of average efficiency on pentane what will be the CO₂ emissions per GJ of useful energy extracted from the engine?

(c) Describe the operation of an electrostatic precipitator and where such a device is used.

Q.5 Write detailed notes on three of the following:

- (a) A gamma ray sterilization plant.
- (b) Non-ionising radiation safety.
- (c) The scintillation counter.
- (d) Units of measurement used for ionising radiation. Recommended dose limits.
- (e) Laser safety.

Q.6 Write an essay on the sources of ionising radiation to which we are exposed, including the relative magnitudes involved. In your answer emphasise the radon problem; its origins, its health effects. Also mention the alleged problem (Henshaw et al) of power lines and radon.

Q.7 Explain what are meant by the following terms:

Mixing ratio, dew point temperature, saturation water vapour pressure, relative humidity.

Describe briefly a method for the measurement of relative humidity.

Determine the rise in temperature of 1 m³ of air due to the heat released by condensation of 1 g of water vapour.

Heat of vaporisation of water	= $2.26 \times 10^6 \text{ J kg}^{-1}$
Specific heat capacity of air	= $1.01 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$
Density of air	= 1.20 kg m^{-3}

Q.8 Answer (A) or (B)

(A) Explain what are meant by the following terms:

Aerosol, isometric particle, equivalent volume diameter, Feret's diameter, polydispersion.

Give a short account of ozone formation and destruction in the atmosphere.

(B) In relation to sound, explain the meaning of four of the following terms: decibel scale; A weighting; reverberation time; audiometry; octave band analysis; permanent threshold shift.

Describe briefly the principal pathways by which the noise of a machine can spread through a building. Discuss the options open to employers to reduce the exposure of their employees to noise from machinery before resorting to personal protective equipment, such as ear defenders.

If the noise level in a room is 89 dBA when four identical machines are operating, what is the level when one is operating ? (Take the background noise level as 75 dBA).

If the noise level at a distance of 25 metres from an outdoor source is 63 dBA what would be the level expected at 50 m from the same source ?