PAM2011 – Semester II Practice Questions – Hints and Solutions

1. A certain type of cell has a radiation response that follows the **multi-target single-hit model** with 4 target molecules. Beyond the threshold dose, an average dose of 50 mGy is required to reduced the cell population to 37% of its original population. What fraction of the cell population would survive a dose of 60 mGy?

Solution:

[10]

$$S = N / N_o = 1 - (1 - e^{-D/D_0})^n$$

$$= 1 - (1 - e^{-1.2_0})^4 = 1 - (1 - 0.301)^4 = 0.76$$

or 76%

2. Discuss the following terms in relation to measurement of Absorbed Dose (i) Absolute Standards, (ii) Secondary, and (iii) Standards Substandard. [6]

Hints:

The following points should be considered:

(i) Absolute standards are large and unpractical devices, often limited to large doses

(ii) Secondary standards are calibrated against (i). Compromises are made for convenience and lower dose detection

(iii) Substandard, practice device, calibrated against (ii).

3. Why are Absolute Standards of Absorbed Dose rarely used to measure radiation dose? [5]

Hints:

The following points should be considered:

- Often very large devices
- Require precisely controlled temperature and pressure
- Only accurate for very high doses
- Each device is designed for a limited energy range
- Require highly level of training to operate

4. Why is it radiolysis of water a significant factor in radiobiology? [5]

Hints:

Humans are ~80% water. Probability of radiation interaction with water molecules is therefore very high in comparison to other molecules

Energy may be transferred to target molecules via free radicals

5. Explain why Dose-equivalent limits are not a boundary between safety and danger. [5]

Hints:
Since IRR 1999 *Dose-equivalent limits* replace *maximum permissible dose.*
Limits set on Risk-Benefit basis.
Limits are NOT a boundary between safety & danger.
Reflect levels of risk comparable to other activities with acceptable risk.
Prevents occurrence of deterministic effects.
Reduce chance of stochastic effect to acceptable probability.

6. When rats are irradiated with 200 kVp x-rays, 50 Gy is required to produce death. If similar rats are irradiated with 10M-eV proton, only 12.5 Gy is needed. Show that the RBE of the protons is 4? [5]

Solution:
RBE = dose of testradiation/dose of standard radiation = 50/12.5 = 4

7. Show that a 3dB loss is approximately equal to 50%. [5]

Solution:

$$dB = 10\log\left(\frac{I_2}{I_1}\right)$$
$$= 10\log(0.5)$$
$$= 10 \times -0.301$$
$$= -4dB$$

Negative therefore a loss

8. Does Relative Biological Effectiveness (RBE) increase or decrease with Linear Energy Transfer (LET)? [1]

Solution:
Increase

9. Under what conditions would a radiation worker require an electronic (solid state) personnel monitoring device? [3]

Solution:
Where there is a chance that worker may be exposed to an unexpected high dose

10. Explain why air is a useful medium in which to perform dosimetry. [2]

Solution:
Air has a similar average atomic number to soft tissue, ~7.5.

11. Explain why Absorbed Dose, Dose equivalent and Effect Dose all have the same SI units. [5]

Hints:
DE = AD x Q x N

ED = DE x W_T

What are Q, N and W_T? And what are their units?

12. Using numerical examples, demonstrate how the number of target molecules affects a cell cultures ability to sustain sub-lethal damage and recover from a radiation dose. [20]

Hints:

Using the following equation

$$S = N / N_o = 1 - (1 - e^{-D/D_0})^n$$

Choose suitable values of D_o, D and show how varying n affects S.