**Shedding Light on Nuclear Radiation Episode 11: Calculating Equivalent and Effective Doses of Radiation**

Name: _____

| Type of Radiation | Radiation Weighting Factor, $W_R$ |
|---|---|
| alpha | 20 |
| beta | 1 |
| gamma | 1 |
| X-rays | 1 |

1. Why is alpha radiation given a weighting factor of 20, while the other types of radiation have a weighting factor of only 1?

_____
_____
_____
_____
_____

2. In both words and symbols, write the equation that links Absorbed Dose, Equivalent Dose and the Radiation Weighting Factor.

3. A radiology technician is accidentally exposed to 80 micrograys (80 µGy) of X-rays while performing a procedure. Calculate the equivalent dose (in microsieverts, µSv) received by the technician.

4. If the same absorbed dose of 80 µGy were due to alpha particles, calculate the equivalent dose (in µSv) .

5. A worker in a nuclear power plant is exposed to the following doses over the course of a year:
   - 0.005 Gy from beta particles
   - 0.0002 Gy from alpha particles

   (a) Calculate the equivalent dose in sieverts, Sv, for each type of radiation.

   From the beta particles

   _____ sieverts
   _____ millisieverts
   _____ microsieverts

   From the alpha particles

   _____ sieverts
   _____ millisieverts
   _____ microsieverts

   (b) Determine the total equivalent dose received by the worker for the year.

   _____ sieverts _____ millisieverts _____ microsieverts

6. A medical physicist is reviewing records for three patients who each received radiation therapy. The table below shows the absorbed dose for each patient and the type of radiation they were exposed to.

| Patient | Absorbed Dose (Gy) | Radiation Type | Equivalent Dose (Sv) | Ranking |
|---|---|---|---|---|
| A | 0.03 | gamma | | |
| B | 0.005 | beta | | |
| C | 0.001 | alpha | | |

   (a) Complete the table by calculating the equivalent dose for each patient.
   (b) Rank the patients in order of total radiation risk based on their equivalent doses.
   (c) If a new guideline limits the annual equivalent dose to 0.05 Sv, determine if any of the patients exceed this limit. _____

| Tissue | Tissue Weighting Factors ($W_T$) |
|---|---|
| stomach | 0.12 |
| lung | 0.12 |
| red bone marrow | 0.12 |
| colon | 0.12 |
| breast | 0.12 |
| gonads (ovaries in women, testes in men) | 0.08 |
| oesophagus | 0.04 |
| liver | 0.04 |
| bladder | 0.04 |
| thyroid | 0.04 |
| bone surfaces | 0.01 |
| brain | 0.01 |
| skin | 0.01 |
| salivary glands | 0.01 |
| rest of the body* | 0.12 |
| TOTAL | 1.00 |

*including uterus and cervix for women or prostate for men, muscle, lymph nodes, kidney, spleen, thymus, heart, gall bladder, small intestine, pancreas, oral mucosa, extrathoracic region, adrenals

7. Write down the equation that relates effective dose, equivalent dose, and tissue weighting factors.

8. A patient undergoing radiotherapy for lung cancer receives an equivalent dose of 20,000 microsieverts targeted at the lungs.
(a) Calculate the effective dose (in microsieverts, µSv) received by the patient during treatment.

(b) Radiotherapy doses are often high but carefully localized to minimize harm. If the entire body had received the same equivalent dose, calculate the effective dose for whole-body exposure (assuming $W_T$ =1 for the entire body).

(c) Discuss why the localized treatment approach is safer for the patient. _____
_____
_____
_____

9. A patient is undergoing radiotherapy for a tumour located on the stomach. During the treatment, the following **equivalent doses** are delivered over the course of the therapy to the stomach and to the liver (which is close to the stomach):
- Stomach: 8,000 µSv
- Liver: 3,000 µSv

(a) Calculate the total effective dose (in microsieverts, µSv) to the patient.

(b) Discuss why it is important to consider the tissue weighting factors when assessing the overall risk to the patient. _____
_____
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