NTNU – Trondheim
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Department of Physics

Examination paper for

TFY 4315
Biophysics of Ionizing Radiation

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Examination date:	**Tuesday 04.06.2013**
Examination time (from-to):	**15:00 – 19:00**
Permitted examination support material:	**D / No written or handwritten examination support materials are permitted. A specified, simple calculator is permitted.**
Other information:	**The examination paper is worked out by Anne Beate Langeland Marthinsen and Tore Lindmo**
Language:	**English**
Number of pages:	**3**
Number of pages enclosed:	**0**

Checked by:

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Date Signature

The count (in percent) for each problem is indicated:

Problem 1 (10 %)

a) Why does radiation with for example x-rays on a human have much higher biological effect than equal amount of energy transferred in form of heat or mechanical energy?

b) Define what we mean by ***Linear energy transfer*** (LET).

c) For a given type of radiation**;** what happens to LET when the radiation energy increases?

Problem 2 (25 %)

a) An individual is exposed to radiation. Define by introducing radiation and tissue weighting factors what is ment by:
   - Absorbed dose
   - Equivalent dose
   - Effective dose

   Indicate the units used for each type of dose.

b) What are the radiation weighting factors for
   - Photons
   - Electrons
   - Protons
   - α-particles
   - Neutrons

c) In radiation therapy patients can be given total doses which are much larger than lethal doses corresponding to acute radiation syndrome (ARS). Why is that tolerated? Give estimates of total doses associated with:
   - curative external photon radiation therapy
   - acute radiation syndrome

Problem 3 (10 %)

a) Delineate the dose-response relationships for tumor control probability and normal tissue damage for a situation favorable for radiation therapy. What do we mean by ***therapeutic ratio*** (therapeutic index***)***? Indicate in the figure a dose giving a favorable therapeutic ratio.

b) How can the therapeutic ratio be manipulated to give a therapeutic gain?

Problem 4 (35 %)

a) Two different mathematical models (the target theory and the linear-quadratic model) explain the shape of the dose survival curve for irradiated clonogenic cells *in vitro*. Explain the basis for the models, give adequate equations and define the different parameters used in each model.

The linear-quadratic model is mostly used the latest years. Why?

b) α/β values in the linear-quadratic model are easily found from dose survival relationships in clonogenic assays. How can we infer α/β value from multifraction experiments in **non**clonogenic systems (as scoring of radiation effects on animal skin)?

c) Give representative α/β values for early and late responding tissues.

d) A patient receives external photon radiation therapy to a tumor with a known α/β value. A total dose D with fraction doses d is given. An equivalent total dose corresponding to fraction doses of 2 Gy (EQD_2) can be written:

$$\mathbf{EQD_2 = D\left(\frac{d+\alpha/\beta}{2+\alpha/\beta}\right)}$$

Show how this equation is derived from the basic BED (biologically effective dose) formula.

Problem 5 (20 %)

Radiation with photons is considered as standard therapy for cancer treatment. Neutrons, protons or heavier ions are alternative radiation modalities in cancer therapy. Give an overview of biological gains and disadvantages based on the individual radiation characteristics seen for each of these treatment modalities compared to the standard radiation therapy.