Final Examination
2018/2019 Academic Session

June 2019

JIF460 – Nuclear and Radiation Physics
(Ilmu Fizik Nuklear dan Sinaran)

Time : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SEVEN (7)** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH (7)** muka surat yang bercetak sebelum anda memulakan peperiksaan ini].*

Instructions : Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.

*[**Arahan** : Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris].*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai].

Useful Information:

Speed of light $c = 3.0 \times 10^8$ m s^{-1}

Avogadro's number $N_A = 6.02 \times 10^{23}$ mol^{-1}

Planck constant $h = 6.63 \times 10^{-34}$ J s

Boltzmann constant $k = 1.38 \times 10^{-23}$ J K^{-1}

Permittivity of free space $\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}

Permeability of free space $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

Basic charge $e = 1.6 \times 10^{-19}$ C

Electron rest-mass $m_e = 9.1 \times 10^{-31}$ kg

Proton rest-mass $m_p = 1.6725 \times 10^{-27}$ kg $\equiv 1.0072766$ u

Neutron rest-mass $m_n = 1.6748 \times 10^{-27}$ kg $\equiv 1.0086654$ u

Bohr's radius $a = 5.3 \times 10^{-11}$ m

1 eV $= 1.6 \times 10^{-19}$ J

1 u $\equiv 931$ MeV c^{-2}

1 barn $= 10^{-28}$ m^2

1 fm $= 10^{-15}$ m

1 Ci $= 3.7 \times 10^{10}$ s^{-1}

Period	Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
1	1 H 1.00																	2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.98	16 S 32.07	17 Cl 35.46	18 Ar 39.94
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.8
5	37 Rb 85.47	38 Sr 87.66	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
6	55 Cs 132.91	56 Ba 137.34	57–71 *	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 197.0	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn 222
7	87 Fr (223)	88 Ra 226.05	89–103 **															

*Rare earths

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 152.0	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.92	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97

*Actinides

89 Ac 227	90 Th 232.04	91 Pa 231	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (249)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lw (257)

1.   (a).   Define the half-life of a radioactive sample and also the sketch of the diagram.

Takrifkan setengah-hayat suatu sampel radioaktif dan lakar satu gambar rajah.

(4 marks/*markah*)

(b). 1×10^{-6} g of radioactive substance plutonium-239 is emitting 2300 α-particles per second. Calculate the half-life of plutonium-239.

Satu bahan radioaktif mengandungi 1×10^{-6} g plutonium-239 yang memancarkan 2300 zarah-α per saat. Hitungkan setengah hayat plutonium-239.

(8 marks/*markah*)

(c).   Sufficient amount of ^{113}In activity must be obtained at 10 a.m. Thursday to provide 1200 kBq at 4 p.m. on Friday. How much activity of ^{113}In should be obtained at 10 a.m. on Thursday? (The half-life of ^{113}In is 1.7 hours.)

Keaktifan ^{113}In yang secukupnya mesti diperolehi pada pukul 10 pagi pada hari Khamis untuk menyediakan 1200 kBq pada pukul 4 petang pada hari Jumaat. Berapa banyak keaktifan ^{113}In perlu diperolehi pada pukul 10 pagi pada hari Khamis?

(Setengah-hayat ^{113}In ialah 1.7 jam.)

(6 marks/*markah*)

(d).   The activity of a radioactive substance dropped to 12.5% from its initial amount in 210 s. What is the half-life of the radioactive substance?

Keaktifan satu sumber radioaktif didapati menurun ke 12.5% daripada keaktifan awal dalam 210 s. Berapakah setengah hayat sumber radioaktif tersebut?

(2 marks/*markah*)

2.   (a).   Given an Au-197 nucleus with a rest-mass of 196.9665 u,

          Diberikan satu nukleus Au-197 berjisim rehat 196.9665 u,

          (i).   estimate the volume of the Au-197 nucleus. Given that R_0 = 1.22 fm.

                anggarkan isipadu nukleus Au-197. Diberikan R_0 = 1.22 fm.

          (ii).   calculate its binding energy per nucleon.

   *hitung tenaga ikatan per-nukleonnya.*

                                                    (12 marks/*markah*)

    (b).   (i).   Define Q-values of a nuclear reaction.

                Takrifkan nilai Q bagi suatu tindak balas nuklear.

                                              (2 marks/*markah*)

          (ii).   Determine the *Q*-values of the following nuclear reaction in MeV and Joules:

$$^2\text{H} + \,^{63}\text{Cu} \longrightarrow \text{n} + \,^{64}\text{Zn}$$
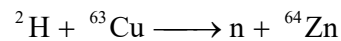
                (Given: Rest-mass of ^2H = 2.014102 u; ^{63}Cu = 62.929599 u; ^{64}Zn = 63.929145 u.)

                Tentukan nilai Q bagi tindak balas nuklear berikut dalam MeV dan Joule:

$$^2\text{H} + \,^{63}\text{Cu} \longrightarrow \text{n} + \,^{64}\text{Zn}$$
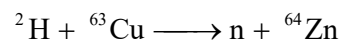
                (Diberikan: jisim rehat ^2H = 2.014102 u; ^{63}Cu = 62.929599 u; ^{64}Zn = 63.929145 u)

                                                (6 marks/*markah*)

3. (a). Stated **THREE** differences between deterministic effects and stochastic effects.

*Nyatakan **TIGA** perbezaan di antara kesan deterministik dan kesan stokastik.*

(6 marks/*markah*)

(b). (i). Defined absorbed dose and equivalent dose.

Takrifkan dos terserap dan dos setara.

(ii). What is the radiation weighting factor (W_R) of X-rays and alpha particle?

Apakah faktor pemberat sinaran (W_R) bagi sinar-X dan zarah alfa?

(6 marks/*markah*)

(c). Describe the production of charateristic X-rays with the help of a diagram.

Terangkan penghasilan sinar-X cirian dengan bantuan satu gambar rajah.

(8 marks/*markah*)

4. (a). Describe the chain reaction process in a nuclear reactor.

Perihalkan proses tindak balas berantai di dalam satu reaktor nuklear.

(10 marks/*markah*)

(b). Discuss **TWO (2)** applications of the nuclear reactor in our daily life.

*Bincangkan **DUA (2)** aplikasi reaktor nuklear dalam kehidupan seharian.*

(10 marks/*markah*)

5. (a). Describe the operating principle of an ionisation chamber with the help of a diagram.

    Jelaskan prinsip operasi kebuk pengionan dengan bantuan satu gambar rajah?

                                                              (10 marks/*markah*)

    (b). Discuss the phosphorescence process in a sodium iodide thalium activated detector.

    Bincangkan proses penderfosfor dalam pengesan teraktif natrium iodide thalium.

                                                              (10 marks/*markah*)

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