



UNIVERSITI SAINS MALAYSIA

Final Examination  
2016/2017 Academic Session

May/June 2017

**JIF 416 – Nuclear and Radiation Physics**  
*[Ilmu Fizik Nuklear dan Sinaran]*

Duration : 3 hours  
*[Masa : 3 jam]*

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Please ensure that this examination paper contains **SIX** printed pages before you begin the examination.

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

Read the instructions carefully before answering.

Each question carries 20 marks.

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

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

*Baca arahan dengan teliti sebelum anda menjawab soalan.*

*Setiap soalan diperuntukkan 20 markah.*

*Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.*

Constants:

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

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

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

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

$$\text{Permittivity of free space } \epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$$

$$\text{Permeability of free space } \mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$$

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

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

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

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

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

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

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

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

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

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

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Period	Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII	
1	1 <b>H</b> 1.00																		2 <b>He</b> 4.00
2	3 <b>Li</b> 6.94	4 <b>Be</b> 9.01											5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18	
3	11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31											13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.98	16 <b>S</b> 32.07	17 <b>Cl</b> 35.46	18 <b>Ar</b> 39.94	
4	19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.71	29 <b>Cu</b> 63.54	30 <b>Zn</b> 65.37	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.91	36 <b>Kr</b> 83.8	
5	37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.66	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (99)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.40	49 <b>In</b> 114.82	50 <b>Sn</b> 118.69	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.30	
6	55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.34	57-71 *	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.09	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.37	82 <b>Pb</b> 207.19	83 <b>Bi</b> 208.98	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> 222	
7	87 <b>Fr</b> (223)	88 <b>Ra</b> 226.05	89-103 **																
	*Rare earths		57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.35	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.92	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.92	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97		
	**Actinides		89 <b>Ac</b> 227	90 <b>Th</b> 232.04	91 <b>Pa</b> 231	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (249)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (253)	101 <b>Md</b> (256)	102 <b>No</b> (254)	103 <b>Lw</b> (257)		

1. (a) Define the half-life of a radioactive sample.  
*Takrifkan setengah-hayat suatu sampel radioaktif*  
(3 marks/markah)
- (b) The half-life of  $^{113}\text{In}$  is 1.7 hours.  
*Setengah-hayat  $^{113}\text{In}$  ialah 1.7 jam.*
- (i) Calculate the number of atoms in  $2\mu\text{g}$  of  $^{113}\text{In}$ .  
*Hitung bilangan atom dalam  $2\mu\text{g}$   $^{113}\text{In}$ .*  
(5 marks/markah)
- (ii) How many  $^{113}\text{In}$  atoms remain after 4 hours have elapsed?  
*Berapa banyak atom  $^{113}\text{In}$  yang tinggal selepas 4 jam berlalu?*  
(4 marks/markah)
- (iii) What is the activity of  $^{113}\text{In}$  at  $t = 4.0$  hours?  
*Apakah aktiviti  $^{113}\text{In}$  pada masa  $t=4$  jam?*  
(4 marks/markah)
- (iv) Enough of  $^{113}\text{In}$  must be obtained at 4pm Thursday to provide 300 kBq at 1pm Friday. How much  $^{113}\text{In}$  should be obtained at 4pm Thursday?  
 *$^{113}\text{In}$  yang secukupnya mesti diperolehi pada jam 4 petang hari Khamis untuk menyediakan 300 kBq pada 1 tengah hari Jumaat. Berapa banyak  $^{113}\text{In}$  perlu diperolehi pada jam 4 petang hari Khamis?*  
(4 marks/markah)

2. (a) Explain the meaning of electron capture in a decay process and its effects.

*Terangkan maksud penangkapan elektron dalam proses pereputan dan kesannya.*

(6 marks/markah)

- (b) Describe the internal conversion in a decay process and the production of Auger electron.

*Terangkan penukaran dalaman dalam proses pereputan dan penghasilan elektron Auger.*

(8 marks/markah)

- (c) Estimate the volume of a Ag-108 nucleus. Given that  $R_0 = 1.22$  fm.

*Anggarkan isipadu satu nukleus Ag-108. Diberikan  $R_0 = 1.22$  fm.*

(6 marks/markah)

3. (a) State the differences between elastic and inelastic interaction.

*Nyatakan perbezaan antara interaksi kenyal dan tak kenyal.*

(6 marks/markah)

- (b) Describe the photoelectric effect.

*Terangkan kesan fotoelektrik.*

(6 marks/markah)

- (c) With the help of diagrams, stated the differences between Bremsstrahlung and Characteristic X-rays in term of their production and spectrum.

*Dengan bantuan gambar rajah, nyatakan perbezaan di antara sinar-x cirian dan sinar-x Bremsstrahlung dari segi penghasilan dan spektrum.*

(6 marks/markah)

- (d) What is the minimum energy (threshold energy) required for pair production?

*Apakah tenaga minimum (tenaga ambang) yang diperlukan untuk penghasilan pasangan?*

(2 marks/markah)

4. (a) Compare the constructions of two types of radiation detectors using different detection method.

*Bandingkan binaan dua jenis pengesan sinaran yang berlainan jenis kaedah pengesanan?*

(10 marks/markah)

- (b) With the help of diagrams, explain the operating principle of one of the radiation detector.

*Dengan bantuan gambar rajah, jelaskan prinsip operasi salah satu pengesan sinaran tersebut.*

(10 marks/markah)

5. (a) Describe the applications of nuclear physics in medical imaging.

*Perihalkan penggunaan fizik nukleus dalam pengimejan perubatan.*

(12 marks/markah)

- (b) Discuss the operating principle of a cyclotron in radioisotopes production.

*Bincangkan prinsip operasi suatu siklotron dalam penghasilan radioisotop.*

(8 marks/markah)