IMPORTANT PHYSICAL CONSTANTS:

Charge of electron, e =1.6 x 10^{-19} C
Mass of electron, m = 9.11 x 10^{-31} kg
Planck's constant, h = 6.63 x 10^{-34} J/s
Reydeberg's constant, RH = 109677 cm^{-1}
Speed of light, C = 2.9998 x 10^{8} m/s

Section A: This section contains ONE COMPULSORY question

Question 1 (30 marks)

a) Explain each of the following terms (5 marks)
   i. Black body
   ii. Photo electric effect
   iii. Quantum
   iv. Quality o radiation
   v. The jelly model of an atom
   vi. Moments of inertia

b) Briefly discuss the general properties of waves (4 marks)

c) Briefly outline the limitations of the Bohr's theory of atomic structure. (3 marks)

d) In 1924 a French scientist, Louis de Broglie proposed the wave nature of electrons.
   i. Briefly discuss the Louis de Broglie's postulates on the wave nature of matter. (5 marks)
   ii. What is the momentum and the corresponding de Broglie wavelength of electrons when the accelerating voltage is 56 V? (6 marks)

e) The Schrödinger wave equation may be given as :

$$\nabla^2\Psi_{(x,y,z)} + \frac{8\pi^2 m}{h^2}(E - V)\Psi_{(x,y,z)} = 0$$

   i. Define all the terms in this expression (4 marks)
   ii. Write the expression of the above form of Schrödinger equation for a helium atom. (3 marks)

Section B: This section contains FOUR questions. Answer ONLY TWO questions.

Question 2 (20 marks)

a) Briefly discuss the properties of an acceptable wave equation according to Born's interpretation of the Schrödinger wave equation. (6 marks)

b) Planck was the one who proposed the principle of energy quantization. At the time many classical physicist were reluctant to accept Planck's new and revolutionary ideas of energy quantization.
   i. Outline the four main areas of study for classical physics at the time and explain why classical physicists were reluctant to accept the new ideas from Planck. (4 marks)

ii. Citing specific examples, explain the main limitation of classical physics at the time in explaining certain scientific observations. (2 marks)

c) Briefly discuss Heisenberg's uncertainty principle. (8 marks)

Question 3 (20 marks)

a) Briefly discuss atomic spectroscopy (6 marks)

b) Explain different types of hydrogen atomic emission series (8 marks)

c) Work out and sketch d orbitals whose angular distribution of the electron density takes the form of the equation, $f = 3cos^2\theta - 1$. (6 marks)

Question 4 (20 marks)

a) By aid of appropriate diagram(s) where necessary, discuss the Rutherford-Geiger experiment. (10 marks)

b) Draw the energy level diagram to show the molecular orbitals of carbon(II) oxide, CO. (4 marks)

Using the above diagram, determine:

i. Electronic configuration, (1 mark)

ii. Magnetic properties and (3 marks)

iii. Bond order of CO (2 marks)

Question 5 (20 marks)

a) Briefly discuss different types of molecular orbitals. (6 marks)

b) Suppose the velocities of an electron (mass 9.11 x 10^{-31} kg) and that of the rifle bullet (mass 0.03 kg) were measured with uncertainty of $\Delta V = 10^{-3}$ m/s. Calculate the minimum uncertainties in their positions according to the uncertainty principle. (8 marks)

c) Sketch the shapes of each of the following orbitals: (6 marks)

i. px

ii. dyz

iii. dz^2

-END-

LIST OF ELEMENTS

Element	Symbol	Atomic no.	Atomic weight	Element	Symbol	Atomic no.	Atomic weight
Actinium	Ac	89	(227)	Mercury	Hg	80	200.59
Aluminium	Al	13	26.981 539	Molybdenum	Mo	42	95.94
Americium	Am	95	(243)	Neodymium	Nd	60	144.24
Antimony	Sb	51	121.75	Neon	Ne	10	20.179 7
Argon	Ar	18	39.948	Neptunium	Np	93	(237)
Arsenic	As	33	74.921 59	Nickel	Ni	28	58.69
Astatine	At	85	(210)	Niobium	Nb	41	92.906 38
Barium	Ba	56	137.327	Nitrogen	N	7	14.006 74
Berkelium	Bk	97	(247)	Nobelium	No	102	(255)
Beryllium	Be	4	9.012 182	Osmium	Os	76	190.2
Bismuth	Bi	83	208.980 37	Oxygen	O	8	15.999 4
Boron	B	5	10.811	Palladium	Pd	46	106.42
Bromine	Br	35	79.904	Phosphorus	P	15	30.973 762
Cadmium	Cd	48	112.411	Platinum	Pt	78	195.08
Caesium	Cs	55	132.905 43	Plutonium	Pu	94	(244)
Calcium	Ca	20	40.078	Polonium	Po	84	(209)
Californium	Cf	98	(251)	Potassium	K	19	39.098 3
Carbon	C	6	12.011	Praseodymium	Pr	59	140.907 65
Cerium	Ce	58	140.115	Promethium	Pm	61	(145)
Chlorine	Cl	17	35.452 7	Protactinium	Pa	91	231.035
Chromium	Cr	24	51.996 1	Radium	Ra	88	226.025 4
Cobalt	Co	27	58.933 20	Radon	Rn	86	(222)
Copper	Cu	29	63.546	Rhenium	Re	75	186.207
Curium	Cm	96	(247)	Rhodium	Rh	45	102.905 50
Dysprosium	Dy	66	162.50	Rubidium	Rb	37	85.467 8
Einsteinium	Es	99	(254)	Ruthenium	Ru	44	101.07
Erbium	Er	68	167.26	Samarium	Sm	62	150.36
Europium	Eu	63	151.965	Scandium	Sc	21	44.955 910
Fermium	Fm	100	(257)	Selenium	Se	34	78.96
Fluorine	F	9	18.998 403 2	Silicon	Si	14	28.085 5
Francium	Fr	87	(223)	Silver	Ag	47	107.8682
Gadolinium	Gd	64	157.25	Sodium	Na	11	22.989 768
Gallium	Ga	31	69.723	Strontium	Sr	38	87.62
Germanium	Ge	32	72.61	Sulphur	S	16	32.066
Gold	Au	79	196.966 54	Tantalum	Ta	73	180.947 9
Hafnium	Hf	72	178.49	Technetium	Tc	43	(97)
Helium	He	2	4.002 602	Tellurium	Te	52	127.60
Holmium	Ho	67	164.930 32	Terbium	Tb	65	158.925 34
Hydrogen	H	1	1.007 94	Thallium	Tl	81	204.383 3
Iodine	I	53	126.904 47	Thulium	Tm	69	168.934 21
Indium	In	49	114.82	Thorium	Th	90	232.038 1
Iridium	Ir	77	192.22	Tin	Sn	50	118.710
Iron	Fe	26	55.847	Titanium	Ti	22	47.88
Krypton	Kr	36	83.80	Tungsten	W	74	183.85
Lanthanum	La	57	138.905 5	Uranium	U	92	238.028 9
Lawrencium	Lr	103	(260)	Vanadium	V	23	50.941 5
Lead	Pb	82	207.2	Xenon	Xe	54	131.29
Lithium	Li	3	6.941	Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.967	Yttrium	Y	39	88.905 85
Magnesium	Mg	12	24.305 0	Zinc	Zn	30	65.38
Manganese	Mn	25	54.938 05	Zirconium	Zr	40	91.224
Mendelevium	Md	101	(258)				