ENGLISH VERSION

PART A: Answer all questions in this section

Question 1 **(15 marks)**

CO1								CO2						
1.2	1.3	1.8	1.9	1.10	1.11	1.13	1.15	1.1	1.4	1.5	1.6	1.7	1.12	1.14
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

1.1 In a......................, about 94 % of the total energy is released in the fuel, 5% is released in the moderator, while the rest is released in pressure tubes, coolant and shielding.

(A) Light-water reactor (B) Gas-Cooled Reactor

(C) Liquid Metal Cooled Reactor (D) CANDU-type reactor

1.2 In a homogeneous core, there are..

(A) no individual fuel elements (B) individual fuel elements

(C) vertical individual fuel elements (D) horizontal no individual fuel element

1.3 In the reactor shutdown, the reactor power does not immediately drop to zero, but falls off rapidly according to a.......................................

(A) positive period (B) high period

(C) negative period (D) period

1.4 The amount of shutdown power generation depends on ....

(A) power before shutdown (P_0) and time after shutdown (T_s)

(B) power and length of time before shutdown (P_0) and (T_0)

(C) power and length of time after shutdown (P_s) and (T_s)

(D) power after shutdown (P_s) and time before shutdown (T_0)

1.5 In the United States, such systems are called Systems for Nuclear Auxiliary Propulsion (SNAP). These SNAP devices are given odd numbers using .... for heat generation.

(A) radioisotopes (B) small fission reactors

(C) accelerator (D) nuclear power plant

1.6 The special case for general heat-conduction equation of steady state and no heat generation is given by..

(A) Helmholtz equation
(B) Fourier equation
(C) Poisson equation
(D) Laplace equation

1.7 In steady state since there is..in the cladding material, the amount of heat leaving surface (S) same as that leaving surface (C).

(A) no heat generated
(B) heat generated
(C) no heat conduct
(D) heat conduct

1.8 ....beams are attenuated as they penetrate thicknesses of bodies.

(A) Neutron and γ alpha
(B) Neutron and γ photon
(C) Neutron and γ photon
(D) Beta and γ photon

1.9 The absorbed radiation is converted into ....that should be removed from these bodies.

(A) radiation
(B) heat
(C) thermal neutron
(D) γ- photon

1.10 Thermal shields must have...

(A) high absorption coefficients and low thermal conductivity
(B) low absorption coefficients and high thermal conductivity
(C) low absorption coefficients and low thermal conductivity
(D) high absorption coefficients and high thermal conductivity

1.11 In the case of neutrons, interaction with materials results in secondary radiations.They result in .... particles, which are of extremely short range.

(A) (n,p) and (n,α)
(B) (n,n)
(C) (n, γ)
(D) A, B and C

1.12 The choice of fin material for a fuel element is a function of ....
and ....

(A) a low neutron absorption cross sections and good thermal conductivity

(B) a high neutron absorption cross sections and bad thermal conductivity

(C) a high neutron absorption cross sections and good thermal conductivity

(D) a low neutron absorption cross sections and bad thermal conductivity

1.13 Major disadvantages of oxide fuels are ....

(A) lower density and lower thermal conductivity

(B) higher density and higher thermal conductivity

(C) lower density and higher thermal conductivity

(D) higher density and lower thermal conductivity

1.14 A reactor with a negative temperature coefficient is therefore ....

(A) not safe (B) inherently safe

(C) super critical (D) criticality

1.15 Shielding materials are not required for ……................…..... ……......…….radiation.

(A) neutron and tritium (B) gamma and proton

(C) alpha and beta (D) neutrino and fission fragment

PART B: ANSWER THREE (3) QUESIONS ONLY. (QUESTION NO. 2, 3 AND ANY 1 (ONE) QUESTIONS FROM EITHER QUESTION NO. 4 OR 5.)

Question 2 (30 marks)

CO4	CO5	CO6	CO7
c	a	~~b~~	~~d~~
12	3	~~5~~	~~10~~

a) What are the characteristics for the thermal shields in a reactor. (3 marks).

b) What is the definition of Prandtl number? By comparing liquid metals and oils, which fluid has thicker thermal boundary layer? Explain why? (5 marks)

c) Heavy-water-cooled research reactor with natural uranium metal rods 0.7 in. in diameter clad with 0.03-in.-thick aluminum. The maximum temperature in the fuel at a certain cross section in the rod is 950°F. The coolant bulk temperature at the cross section is 350 °F. The heat-transfer coefficient is 6500 Btu/hr ft^2 of. Determine for the above cross section

i. the neutron flux (thermal);
ii. the specific power, kw/kgm fuel;
iii. the maximum cladding temperature:
iv. the maximum coolant temperature;
v. the minimum coolant pressure to avoid boiling; and
vi. the theoretical maximum flux beyond which the above maximum fuel temperature cannot be maintained (12 marks)

d) Light liquid water is used as a reactor coolant. In a particular channel, the average bulk temperature is 150°C. Determine the precenty change in W/q if it were to be used in the same channel, with the same mass flow rate, the same mean temperature between cladding and coolant, but at average bulk temperatures of 100°C and 200°C. (10 marks)

Question 3 (30 marks)

CO	CO2	CO3	CO5	CO6	CO7
	b	d	c	~~e~~	~~a~~
Marks	5	5	7	~~10~~	~~3~~

a) Sketch the boiling curve and identify all important features of the curve. Explain how burnout is caused. Why is the burnout point avoided in the design of light water reactors? (3 marks)

b) For a spherical thermal reactor with a water moderator in a homogeneous mixture, what is the value of the infinite multiplication factor necessary for the reactor to be critical? The radius of the reactor is 1 m. (5 marks)

c) A 3-in.-thick flat-plate iron shield is subjected at one face to 3.0 Mev/photon gamma radiation of uniform 10^{13} flux. If the temperature of both sides of the plate were to remain equal find

i. The position within the plate at which the maximum temperature occurs;
ii. The surface cooling on each side of the plate, in Btu/hr ft, necessary to maintain the above conditions;
iii. The difference between maximum and surface temperatures. (7 marks)

d) Determine the volumetric thermal source strength (power density) of 12 % enriched UO_2 fuel in a heavy water reactor. The moderator temperature at the same core position is 550°F. The average neutron flux is 8×10^{15} cm^{-2} s^{-1}. The fission cross section is 579 b. The density of UO_2 is 10.5 g/cm^3. (5 marks)

e) Estimate the bottom surface temperature of the pan in Figure 1 below, neglecting conduction resistance of the pan. Emissivity of hot plate $\varepsilon_1 = 0.7$, Emissivity of bottom surface of pan $\varepsilon_2 = 0.9$ (10 marks)

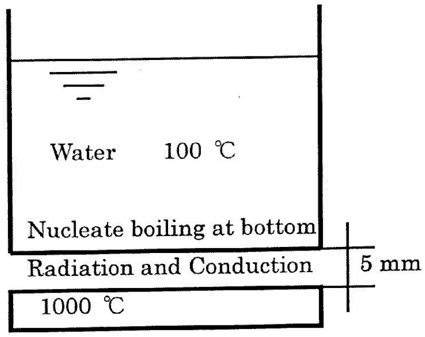

Figure 1

Parameters

Thermal conductivity of air $k_a = 0.057$ W/mK
Specific heat of water $c_l = 4.215$ kJ/kgK
Latent heat of water $h_{fg} = 2{,}256$ kJ/kg
Water Prandtl number Pr = 1.76
Viscosity ow water $\mu_l = 282.7 \times 10^{-6}$ Pas
Surface tension of water $\sigma = 58.917 \times 10^{-3}$ N/m
Gravitational acceleration $g = 9.807$ m/s^2
Density of water $\rho_l = 958.0$ kg/m^3
Density of vapor $\rho_g = 0.6037$ kg/m^3
$C_{sf} = 0.013$
Stefan-Boltzmann constant $\sigma = 5.6697 \times 10^{-8}$ W/m^{2}K^4

Taking T_l = hot plate temperature, T_2 = bottom surface of pan temperature, T_w = surface temperature of pan on water side, T_s = boiling water temperature.

Between hot plate and pan, both conduction and radiation modes of heat transfer occur in parallel.

For conduction,

$$q_{cond} = -\mathrm{k}\frac{dT}{dx} = -k\frac{(T_1 - T_2)}{\delta}$$

For radiation,

$$q_{rad} = \sigma(T_1^4 - T_2^4)\frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

Question 4 (25 marks)

CO1	CO2	CO4
a	**c**	**b**
5	**10**	**10**

a) Develop a relationship between the thermal fission factor η for uranium fuels and v for . U^{235} in terms of the microscopic fission (σ_f) and absorption cross sections (σ_a) and the enrichment. (5 marks)

b) Show that Equation $T_m - T_s = \frac{q''' R^2}{4k_f}$ can be written as $T_m - T_s = \frac{q'}{4\pi k_f}$ where q' is the heat generated per unit length of a fuel rod. What you can conclude from the equation and where is this parameter is usefuel. (10 marks)

c) A reactor generates 2,000 Mw(t) for a year or more. Find the amount of heat in Btu that must be removed from the core during

i. the first hour, and
ii. 1 year , following shutdown. (10 marks)

Question 5 (25 marks)

CO1	CO2	CO4
a	c	b
5	10	10

a) A Define the volumetric thermal source strength. (5 marks)

b) A heterogeneous cylindrical reactor core contains 10,000 fuel rods. The maximum thermal-neutron flux is $4x10^{13}$ n/see $cm^2$and the fuel enrichment is 3 percent. The average moderator temperature is 300 ^{o}F. The fuel pellets are 0.5 in. in diameter. The core is 6 ft in diameter and 16 ft high. Neglecting the extrapolation lengths, calculate the total heat generated in the core in kW (t). The fuel is UO_2 and the moderator is heavy water. (10 marks)

c) A fast-reactor fuel material is composed of 35 percent by mass of $Pu^{239}O_2$ and 65 percent by mass UO_2 . The U is depleted uranium and may be considered to be all U^{238}. The density of the fuel material is 10 gm/cm^3. Calculate the nuclear densities, in nuclei/cm3 , of Pu^{239} and U^{238} . (10 marks)