ENTRANCE EXAMINATION FOR ADMISSION, MAY 2013.

Ph.D. (ENVIRONMENTAL TECHNOLOGY)

COURSE CODE : 112

Register Number : [ ]

Signature of the Invigilator
(with date)

COURSE CODE : 112

Time : 2 Hours Max : 400 Marks

Instructions to Candidates :

1. Write your Register Number within the box provided on the top of this page and fill in the page 1 of the answer sheet using pen.
2. Do not write your name anywhere in this booklet or answer sheet. Violation of this entails disqualification.
3. Read each of the question carefully and shade the relevant answer (A) or (B) or (C) or (D) in the relevant box of the ANSWER SHEET using HB pencil.
4. Avoid blind guessing. A wrong answer will fetch you –1 mark and the correct answer will fetch 4 marks.
5. Do not write anything in the question paper. Use the white sheets attached at the end for rough works.
6. Do not open the question paper until the start signal is given.
7. Do not attempt to answer after stop signal is given. Any such attempt will disqualify your candidature.
8. On stop signal, keep the question paper and the answer sheet on your table and wait for the invigilator to collect them.
9. Use of Calculators, Tables, etc. are prohibited.

1. Dimensional formula for angular momentum is:

(A) T^{-1} (B) MLT^{-1} (C) ML^2T^{-1} (D) $M^0L^0T^0$

2. The force F and density d are related by $F = x/\sqrt{d}$

The dimensions of x are:

(A) $M^{3/2}L^{-1/2}T^2$ (B) $M^{3/2}L^{1/2}T^{-2}$ (C) $M^{3/2}L^{-1/2}T^{-2}$ (D) $M^{-3/2}L^{1/2}T^{-2}$

3. The displacement-time graph for the two particles A and B are straight lines inclined at angles of 30°and 60° with the time axis. The ratio of the velocities $V_A : V_B$ will be:

(A) 1:2 (B) $1:\sqrt{(3)}$ (C) $\sqrt{(3):1}$ (D) 1:3

4. A motor car moving with a uniform speed of 20 m/sec comes to stop on the application of brakes after travelling a distance of 10 m. Its acceleration is:

(A) 20 m/sec^2 (B) –20 m/sec^2 (C) –40 m/sec^2 (D) +2 m/sec^2

5. A body thrown up with a finite speed is caught back after 4 sec. The speed of the body with which it is thrown up is:

(A) 10 m/sec (B) 20 m/sec (C) 30 m/sec (D) 40 m/sec

6. If X, F and U denote the displacement, force acting and potential energy of a particle, then:

(A) $U = FX$ (B) $F = +\frac{dU}{dX}$ (C) $F = -\frac{dU}{dX}$ (D) $F = \frac{1}{x}.\frac{dU}{dX}$

7. A planet moves around the sun. At a point P it is closest from the sun at a distance d_1 and has a speed v_1. At another point Q, when it is farthest from the sun at a distance d_2, its speed will be:

(A) $d_1^2 v_1 / d_2^2$ (B) $d_2 v_1 / d_1$ (C) $d_1 v_1 / d_2$ (D) $d_2^2 v_1 / d_1^2$

8. A satellite is orbiting round the earth. The centripetal force on the satellite is F. The gravitational force of the earth on the satellite is also F. The net force on the satellite is:

(A) F (B) zero (C) 2F (D) F/2

9. A ball floats on the surface of water in a container exposed to the atmosphere. If the container is now covered and the air is pumped out, then:

(A) The ball will remain at its former depth

(B) The ball will rise somewhat

(C) The ball will sink to the bottom

(D) The ball will sink a bit

10. Soldering of two metals is possible because of the property of:

(A) Viscosity (B) Surface tension (C) Osmosis (D) Cohesion

11. The viscosity of falling rain drop attains limited value because of:

(A) upthrust of air (B) viscosity force exerted by air

(C) surface tension effects (D) air currents in atmosphere

12. A small steel ball falls through a sysup at a constant speed of 10 cm/sec. If the steel ball is pulled upwards with a force equal to its effective weight, how fast will it move upward:

(A) 10 cm/sec (B) 20 cm/sec (C) 5 cm/sec (D) zero cm/sec

13. A gas in a container 1 is in thermal equilibrium with another gas in a container 2. P_1, V_1, T_1 and M_1 denote the pressure, volume, temperature and molecular mass of gas in container 1. The corresponding quantities for gas in container 2 are P_2, V_2, T_2 and M_2. Which of the following relations is correct?

(A) $P_1 = P_2, V_1 = V_2$ (B) $P_1V_1 = P_2V_2$

(C) $\frac{P_1}{V_1} = \frac{P_2}{V_2}$ (D) $\frac{M_1P_1V_1}{M_2P_2V_2}$ = constant

14. 10 gm of ice at -20°C is dropped into a calorimeter containing 10 gm of water at 10°C. The specific heat of water is twice that of ice. When equilibrium is reached, the calorimeter will contain:

(A) 10 gm ice and 10 gm water (B) 20 gm water

(C) 5 gm ice and 15 gm water (D) 20 gm ice

15. Which one of the following is a correct statement:

(A) The dimensional formula for the angular velocity and linear velocity are same

(B) The dimensional formula for wavelength is $M^0L^2T^{-2}$

(C) The dimensional formula for wave number is $M^0L^{-1}T^0$

(D) The dimensional formula for angular momentum and latent heat is same

16. If $x = at + bt^2$, where x is in metres and t is in hour (hr), the units of b will be:

(A) metre (B) $\frac{\text{metre}}{\text{hr}}$ (C) $\frac{\text{metre}}{\text{hr}^2}$ (D) $\frac{\text{metre}^2}{\text{hr}}$

17. A body travelling with uniform acceleration crosses two points A and B with velocities 20 m/sec and 30 m/sec respectively. The speed of the body at mid-point of A and B is:

(A) 25 m/sec (B) 25.5 m/sec (C) 24 m/sec (D) $10\sqrt{6}$ m/sec

18. A bus starts from rest with an acceleration of 1 m/sec2. A man who is 48 m behind the bus starts with a uniform velocity of 10 m/sec, then the minimum time after which the man will catch the bus is:

(A) 12 sec (B) 8 sec (C) 10 sec (D) 4.8 sec

19. A toy of mass M1 is pulled along a horizontal frictionless surface by a rope of mass M_2. A force F is applied to the free end of the rope. The force exerted on the cart is:

(A) F (B) $\frac{FM_1}{M_1+M_2}$ (C) $\frac{FM_1}{M_1-M_2}$ (D) $\frac{FM_2}{M_1+M_2}$

20. A 50 kg man is standing on a flat boat at rest in a river. He moves 5 metres to north and halts. If the boat has a mass of 450 kg, then the boat moves through:

(A) 0.5 metres to the south (B) 0.55 metres to the south

(C) 0.5 metres to the north (D) Zero metre

21. A gun fires a bullet of mass 50 gm with a velocity of 30 m sec-1. Because of this the gun is pushed back with a velocity of 1 m sec^{-1}. The mass of the gun is:

(A) 15 kg (B) 30 kg (C) 1.5 kg (D) 20 kg

22. The force required to keep a body in uniform circular motion is:

(A) centripetal force (B) centrifugal force

(C) resistance (D) none of the above

23. A body is projected in space from earth's surface with escape velocity. At the time of projection its total energy will be:

(A) potential energy (B) kinetic energy

(C) partially K.E. and partially P.E. (D) half K.E. and half P.E.

24. A body floats with one-third of its volume outside water and 3/8 of its volume inside another liquid. The density of other liquid is:

(A) 9/4 gm/c.c. (B) 4/9 gm/c.c. (C) 16/9 gm/c.c. (D) 2/9 gm/c.c.

25. Soap helps in better cleaning of clothes because:

(A) It reduces the surface tension of solution

(B) It gives strength to solution

(C) It absorbs the dirt

(D) Chemical of soaps change

26. Water rises to a height of 10 cm when a glass tube is dipped vertically in it, what will be the rise if the tube is inclined at 30°to the vertical:

(A) $\frac{5\sqrt{3}}{2}$ (B) 10 cm (C) $\frac{20}{\sqrt{3}}$ (D) $\frac{\sqrt{3}}{10}$ cm

27. Oxygen and hydrogen are at the same temperature T. The kinetic energy of the oxygen molecule will be:

(A) 16 times

(B) 4 times

(C) Equal

(D) One-fourth the K.E. of hydrogen molecule

28. The energy of molecular motion appears in the form of:

(A) Friction (B) Heat

(C) Temperature (D) Potential energy

29. Two thermometers, one Celsius and the other Fahrenheit are put in a hot bath. The reading on Fahrenheit thermometer is just three times the reading on Celsius thermometer. The temperature of the bath is:

(A) 100°C (B) 80/3°C (C) 80°C (D) 70°C

30. The dimensional formula for latent heat is

(A) $M^0L^2T^{-2}$ (B) ML^2T^{-2} (C) MLT^{-2} (D) ML^2T^{-1}

31. Melting point of ice

(A) Increases with increasing pressure (B) Decreases with increasing pressure

(C) Is independent of pressure (D) Is proportional to pressure

32. The excess of pressure in a soap bubble of radius R and surface tension T is given by:

(A) $P = \frac{2T}{R}$ (B) $P = \frac{4T}{R}$ (C) $P = \frac{T}{R}$ (D) $P = \frac{6T}{R}$

33. The total area of cross-section is 0.25 m2. If blood is flowing at the rate of 100 cm^3/sec then the average velocity of flow of blood through the capillaries is:

(A) 0.4 mm/s (B) 4 mm/s (C) 25 mm/s (D) 400 mm/s

34. A circular wire of radius 3 cm. is cut and bent so as to lie along the circumference of a hoop whose radius is 48 cm. The angle in degrees which is subtended at the centre of the hoop is

(A) 15° (B) 22.5° (C) 30° (D) 45°

35. If $\sin\theta = -3/5$ and θ lies in the third quadrant, then the value of $\cos(\theta/2)$ is

(A) $\frac{1}{5}$ (B) $1-/\sqrt{(10)}$ (C) $-1/5$ (D) $1/\sqrt{(10)}$

36. If in a ΔABC, $\sin A = \sin^2 B$ and $2\cos^2 A = 3\cos^2 B$, then the ΔABC is

(A) right angled (B) obtuse angled

(C) isosceles (D) equilateral

37. In a $\Delta ABC, b = \sqrt{3+1}, c = \sqrt{3-1}, \angle A = 60^\circ$, then the value of $\tan \frac{1}{2}(B-C)$ is

(A) 2 (B) 1/2 (C) 1 (D) 3

38. A man in a boat rowed away from a cliff 150 metres high takes 2 minutes to change the angle of elevation of the top of the cliff from 60° to 45°. The speed of the boat is

(A) $\left(9-3\sqrt{3}\right)/2$ km/h (B) $\left(9+3\sqrt{3}\right)/2$ km/h (C) $\left(9\sqrt{3/2}\right)$km/h (D) None of these

39. The complex number $\sin x + i\cos 2x$ and $\cos x - i\sin 2x$ are conjugate to each other for

(A) $x = n\pi$ (B) $x = (n+1/2)\pi$ (C) $x = 0$ (D) No value of x

40. If $2i^2 + 6i^3 + 3i^{16} - 6i^{19} + 4i^{25} = x + iy$, then

(A) $x = 1, y = -4$ (B) $x = 4, y = -1$

(C) $x = 1, y = 4$ (D) $x = -1, y = -4$

41. The line segment joining the points $(1,2)$ and $(-2,1)$ is divided by the line $3x + 4y = 7$ in the ratio

(A) 3:4 (B) 4:3 (C) 9:4 (D) 4:9

42. The ends of the base of an isosceles triangle are at $(2a,0)$ and $(0,a)$ and one side is parallel to y-axis. The equation of the other side is

(A) $x + 2y - a = 0$ (B) $x + 2y = 2a$

(C) $3x + 4y - 4a = 0$ (D) $3x - 4y + 4a = 0$

43. If $(x,3)$ and $(3,5)$ are the extremities of a diameter of a circle with centre at $(2,y)$, then the value of x and y are

(A) $x = 1, y = 4$ (B) $x = 4, y = 1$

(C) $x = 8, y = 2$ (D) None of these

44. The equation of the circumcircle of the triangle formed by the lines $y + \sqrt{3x} = 6$, $y - \sqrt{3x} = 6$ and $y = 0$ is

(A) $x^2 + y^2 - 4y = 0$ (B) $x^2 + y^2 + 4x = 0$

(C) $x^2 + y^2 - 4y = 12$ (D) $x^2 + y^2 + 4x = 12$

45. If $f(x)=\log\left(\frac{1+x}{1-x}\right)$ and $-1<x,x_2<1$, then $f(x_1)-f(x_2)$ is equal to

(A) $f\{(x_1-x_2)/(1+x_1x_2)\}$ (B) $f\{(x_1-x_2)/(1-x_1x_2)\}$

(C) $f\{(x_1+x_2)/(1-x_1x_2)\}$ (D) $f\{(x_1+x_2)/(1+x_1x_2)\}$

46. $\lim_{x\to 0}\frac{\log\cos x}{x}$ is equal to

(A) 0 (B) ∞ (C) 1 (D) None of these

47. The value of a so that $f(x)=\sin^2 ax/x^2$, $x\neq 0$, $f(0)=1$, is continuous at $x=0$ is

(A) 0 (B) only 1 (C) only -1 (D) ± 1

48. If $y=\sin^{-1}\left[\frac{1-x^2}{1+x^2}\right]$ is equal to

(A) $-2/(1+x^2)$ (B) $2/(1+x^2)$ (C) $1/(2+x^2)$ (D) $2/(2-x^2)$

49. If $x=0\sin 2\theta$, $y=\theta\cos 2\theta$, then $\frac{dy}{dx}$ at $\theta=\pi/4$ is

(A) 1/2 (B) $-1/2$ (C) $\pi/2$ (D) $-\pi/2$

50. If $x=t+\frac{1}{t}$, $y=t-\frac{1}{t}$, then d^2y/dx^2 is

(A) $-4t/(t^2-1)$ (B) $-4t^3/(t^2-1)^3$ (C) $(t^2+1)/(t^2-1)$ (D) $-4t^2/(t^2-1)^2$

51. If $z=\cos(xy^3)$, then $\partial^2 z/\partial x\partial y=$

(A) $-6xy\sin(xy^3)+9x^2y^4\cos(xy^3)$ (B) $6xy\sin(xy^3)-9x^2y^4\cos(xy^3)$

(C) $-6xy\sin(xy^3)-9x^2y^4\cos(xy^3)$ (D) $6xy\sin(xy^3)+9x^2y^4\cos(xy^3)$

52. If $z=\tan^{-1}(y/x)$, then $z_{xx}+z_{yy}=$

(A) 0 (B) $x/(x^2+y^2)^2$ (C) $y/(x^2+y^2)^2$ (D) None of these

53. The value of a for which the difference of the roots of the equation $ax^2+(a-1)x+2=0$ is min, is given by

(A) 1/5 (B) 5 (C) $-1/5$ (D) None of these

54. When a stone is thrown upwards on $s = 10t-3t^2$ in metres and seconds. It will fall back (on the planet) again after

(A) (20/3) sec (B) (10/3) sec (C) (5/3) sec (D) None of these

55. $\int_2 \frac{\sqrt{\{(x-4)\}}}{x} dx =$

(A) $2\left(3\sqrt{3-\pi}\right)/3$ (B) π (C) $2\left(3\sqrt{3-\pi}\right)$ (D) None of these

56. $\int_2^4 \frac{dx}{\sqrt{\{(x-2)(4-x)\}}} =$

(A) $\pi/2$ (B) π (C) 0 (D) None of these

57. Area common to the parabolas $y = 2x^2$ and $y = x^2 + 4$ is

(A) 16/3 (B) 8/3 (C) 32/3 (D) None of these

58. Equation of the curve through the point (1, 0) which satisfy the differential equation $(1+y^2)dx - xydy = 0$ is

(A) $x^2 + y^2 = 1$ (B) $x^2 - y^2 = 1$ (C) $2x^2 + y^2 = 2$ (D) None of these

59. If $a.b = a.c$ and $a \times b = a \times c$, then

(A) either $a = 0$ or $b = c$ (B) a is parallel to $(b - c)$

(C) a is perpendicular to $(b - c)$ (D) None of these

60. If vectors $(x-2)a + b$ and $(2x+1)a - b$ are parallel, then $x =$

(A) 1/3 (B) 3 (C) –3 (D) –1/3

61. If x_1, x_2, x_3 are distinct roots of the equation $ax^2 + bx + c = 0$, then

(A) $a = b = 0,\ c \in R$ (B) $a = b = 0, b \in R$ (C) $b^2 = 4ac \geq 0$ (D) $a = b = c = 0$

62. A five digit number is formed by the digits 1, 2, 3, 4, 5, 6 and 8. The probability that the number has even digit at both ends is

(A) 2/7 (B) 3/7 (C) 4/7 (D) None of these

63. If $f(x) = \cos^2 x + \sec^2 x$, its value always is

(A) $f(x) < 1$ (B) $f(x) = 1$ (C) $2 > f(x) > 1$ (D) $f(x) \geq 2$

64. If $\sin\theta + \cos\theta = 1$, then the value of sin 2θ is

(A) 1 (B) 1/2 (C) 0 (D) None of these

65. If $x = \frac{1}{2}\left(\sqrt{3} + i\right)$, then x^3 is

(A) 1 (B) –1 (C) i (D) $-i$

66. If $a+b+c=0$, the straight line $2ax+3by+4c=0$ passes through the fixed point

(A) (2, 4/3) (B) (2, 2)

(C) (4/3, 4/3) (D) no such fixed point

67. Equation of the diameter of the circle $x^2 + y^2 - 2x + 4y = 0$ which passes through the origin is

(A) $x+2y=0$ (B) $x-2y=0$ (C) $2x+y=0$ (D) $2x-y=0$

68. Assuming salts to be 90% dissociated which of the following will have highest osmotic pressure?

(A) Decinormal $Al_2(SO_4)_3$

(B) Decinormal $BaCl_2$

(C) Decinormal Na_2SO_4

(D) A solution obtained by mixing equal volumes of (b) and (c) and filtering

69. A sample of water is distilled at 2 atmospheric pressure. The boiling point will be?

(A) 100°C (B) 200°C (C) 300°C (D) None

70. On the basis of relative strengths of intermolecular forces predict the correct order of decreasing boiling points of the compounds

(A) $CH_3OH > H_2 > CH_4$ (B) $CH_3OH > CH_4 > H_2$

(C) $CH_4 > CH_3OH > H_2$ (D) $H_2 > CH_4 > CH_3OH$

71. The blue colour of water in the sea is due to?

(A) Absorption of other colours except blue by water molecules

(B) Scattering of blue light by water molecules

(C) Refraction of blue light by impurities in sea water

(D) Reflection of blue sky by sea water

72. The system $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ attains equilibrium. If the equilibrium concentration of PCl_3 is doubled, the concentration of Cl_2 would become?

(A) Half its original value (B) Twice of its original value

(C) One fourth of its original value (D) None

73. For the exothermic reaction $2NO\ (g) \rightleftharpoons N_2\ (g) + O_2\ (g)$ + heat?

(A) K increases with temperature (B) K is independent of temperature

(C) K decreases with temperature (D) K varies with addition of N_2 or O_2

74. The order of reaction can be deduced from?

(A) Chemical equation (B) Experiment

(C) Rate constant (D) Thermochemical equation

75. Consider a gaseous reaction, the rate of which is given by k[A] [B]. The volume of the reaction vessel containing these gases is suddenly reduced to one fourth the initial volume. The rate of reaction relative to the original rate would be?

(A) 16/1 (B) 1/16 (C) 8/1 (D) 1/8

76. On combustion, carbon forms two oxides CO and CO_2. Heat of formation of CO_2 is 94.3 K.cals and that of CO is 26.0 K.cals. Heat of combustion of carbon is?

(A) 26.0 K.Cals (B) 94.3 K.Cals (C) 68.3 K.Cals (D) 120.3 K.Cals

77. Which of the following is the weakest acid?

(A) HBr (B) $HClO_4$ (C) H_2SO_4 (D) HNO_3

78. Which of the following shows decrease in solubility with an increase in temperature?

(A) KNO_3 (B) NH_4Br (C) Na_2SO_4 (D) All

79. If a compound has a negative heat of solution, at high temperature it dissolves

(A) More rapidly and is more soluble (B) More rapidly and is less soluble

(C) Less rapidly and is less soluble (D) Less rapidly and is more soluble

80. 0.1 N solution of a compound was prepared from its impure sample. If percentage purity of the compound is to be determined, then the weight of necessary substance will be?

(A) More than the principal weight (B) Less than the principal weight

(C) Equal to the principal weight (D) None of these

81. Which of the following pairs of solutions can we expect to be isotonic at the same temperature?

(A) 0.1 M NaCl and 0.1 M Na_2SO_4 (B) 0.1 M urea and 0.1 M NaCl

(C) 0.1 M urea and 0.2 M $MgCl_2$ (D) 01. M $Ca(NO_3)_2$ and 0.1 M Na_2SO_4

82. The ratio of the value of any colligative property for KCl solution to that of sugar solution is?

(A) 1 (B) 0.5 (C) 2 (D) 4

83. When dispersion medium is water, the colloidal system is called?

(A) Sol (B) Aerosol (C) Organosol (D) Aquasol

84. Which of the following can absorb large volume of hydrogen gas?

(A) Colloidal solution of palladium (B) Finely divided nickel

(C) Finely divided platinum (D) Colloidal $Fe(OH)_3$

85. Raising the temperature of a reversible reaction?

(A) Favours the forward reaction rate only

(B) Favours the backward rate only

(C) Favours the forward and backward rates

(D) Favours neither the forward nor the backward reaction

86. The rate constant of a reaction depends on?

(A) Temperature (B) Mass (C) Weight (D) Time

87. Sometimes reaction rates can be estimated by knowing

(A) The atmospheric pressure (B) The number of bond changes

(C) The net ionic equation (D) Magnitude of negative $\triangle G$

88. In the reaction $2A + B \rightarrow A_2B$, if the concentration of A is doubled and that of B is halved, then the rate of the reaction will?

(A) Increase by 4 times (B) Decrease by 2 times

(C) Increase by 2 times (D) Remains the same

89. Which of the following does not apply to catalytic reactions?

(A) Capability to initiate the non feasible reaction

(B) Specificity

(C) Lowering the activation energies of forward as well as backward reaction

(D) Constancy in value of $\triangle H$

90. Vapourisation is an example of a process for which?

(A) ΔH, ΔS, and ΔG are positive at all temperatures

(B) ΔH and ΔS are positive

(C) ΔG is negative at low T, positive at high T

(D) ΔH is strongly pressure dependent

91. If dissociation energies of methane and ethane are 360 K.cals/mole and 620 K.cals/mole respectively, then bond energy of C-C in K.cals is?

(A) 80 (B) 260 (C) 180 (D) 130

92. How many moles each of Ag^+ ion Cu^{2+} ion and Fe^{3+} ions would be deposited by passage of same quantity of electricity through solutions of their salts?

(A) Same number of moles of each (B) 1 : 1/2 : 1/3 moles

(C) 1/3 : 1/2 : 1 (D) None of these

93. When a lead storage battery is discharged,?

(A) SO_2 is evolved (B) Pb is formed

(C) $PbSO_4$ is consumed (D) H_2SO_4 is consumed

94. A solution of pH 9.0 is one thousand times as basic as a solution of pH?

(A) 6 (B) 7 (C) 4 (D) 10

95. Which of the following is acidic salt?

(A) $(NH_4)_2CO_3$ (B) $KClP_4$ (C) $KHSO_4$ (D) BaO

96. Excessive solubility of alcohol in water is due to?

(A) Covalent bond (B) Ionic bond

(C) Hydrogen bond with water (D) None of these

97. Which one of the following informations can be obtained on the basis of LeChatelier's principle?

(A) Shift in equilibrium position on changing value of a constant

(B) Dissociation constant of a weak acid

(C) Energy change in a reaction

(D) Equilibrium constant of a chemical reaction

98. At room temperature, the reaction between NO and O_2 to give NO_2 is fast, while that between CO and O_2 is slow. It is because?

(A) CO is smaller in size than that of NO

(B) CO is poisonous

(C) The activation energy for the reaction $2NO + O_2 \leftrightarrows 2NO_2$ is less

(D) The intrinsic energy of the reaction $2NO + O_2 \leftrightarrows 2NO_2$ is less

99. An aqueous solution containing one gm of urea boils at 100.25°C. The aqueous solution containing 3gm of glucose in the same volume will boil at?

(A) 100.75°C (B) 100.5°C (C) 100°C (D) 100.25°C

100. Size of colloidal particles varies?

(A) $10^{-6} - 10^{-9}$ m (B) $10^{-9} - 10^{-12}$ m (C) $10^{-3} - 10^{-9}$ m (D) $10^{-12} - 10^{-19}$ m