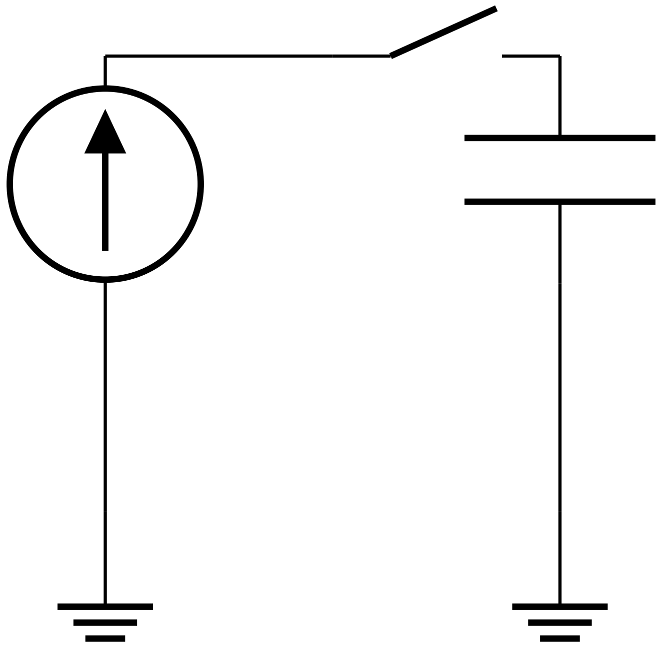
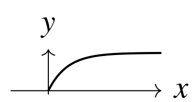
2010-PH-40-52

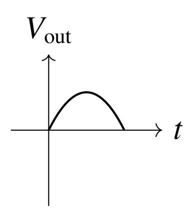
EE24BTECH11001 - ADITYA TRIPATHY

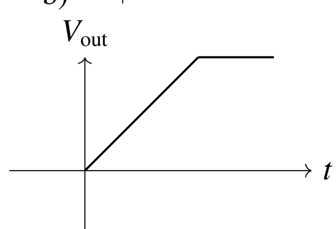
40. The figure shows a current source charging a capacitor that is initially uncharged

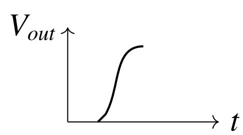


If the switch is closed at $t = 0$, which of the following plots depicts correctly the output voltage of the circuit as a function of time? (2010 – *PH*)

a) 



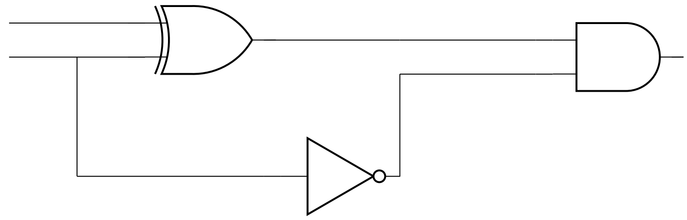
b) 

c) 

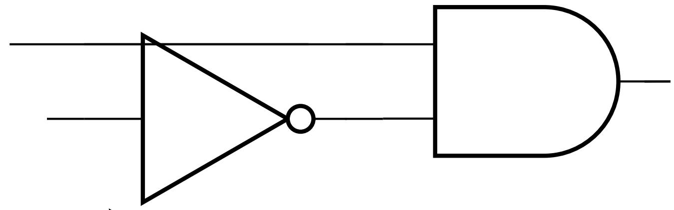
d)

41. For any set of inputs, A and B, the following circuits give the same output , Q, except one. Which one is it?

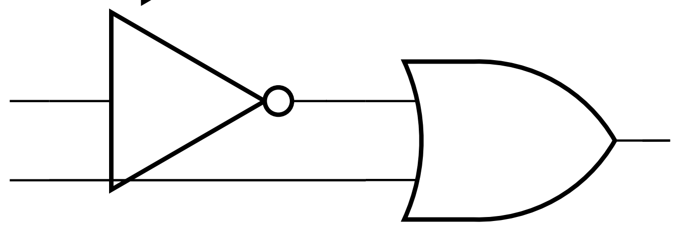
(2010 – *PH*)



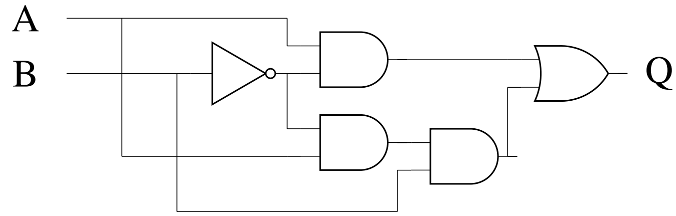
a)



b)



c)



d)

42. CO_2 molecule has the first few energy levels uniformly separated by approximately 2.5 meV. At a temperature of $300K$, the ratio of the number of moleciles in the 4^{th} excited state to the number in the 2^{nd} excited state is about (2010 – PH)
   a) 0.5
   b) 0.6
   c) 0.8
   d) 0.9
43. Which among the following sets of Maxwell relations is correct? (U – internal energy, H – enthalpy, A – Helmho
(2010 – PH)
   a) $T = \left(\frac{\partial U}{\partial V}\right)_S$ and $P = \left(\frac{\partial U}{\partial S}\right)_V$
   b) $V = \left(\frac{\partial H}{\partial P}\right)_S$ and $T = \left(\frac{\partial H}{\partial S}\right)_P$
   c) $P = -\left(\frac{\partial G}{\partial V}\right)_T$ and $V = \left(\frac{\partial G}{\partial P}\right)_S$
   d) $T = -\left(\frac{\partial A}{\partial S}\right)_T$ and $V = \left(\frac{\partial G}{\partial P}\right)_S$
44. For a spin-s particle, the the eigen basis of $\bar{S}.S$, the expectation value $\langle\, sm|S^2,|sm\,\rangle$ is
(2010 – PH)
   a) $\frac{\hbar^2\left\{s(s+1)-m^2\right\}}{2}$
   b) $\hbar^2\left\{s\,(s+1)-2m^2\right\}$
   c) $\hbar^2\left\{s\,(s+1)-m^2\right\}$
   d) $\hbar^2 m^2$
45. A particle is placed in a region with potential $V\,(x) = \frac{1}{2}kx^2 - \frac{\lambda}{3}x^2$, where $k, \lambda > 0$. Then, (2010 – PH)
   a) $x = 0$ and $x = \frac{k}{\lambda}$ are points of stable equilibrium
   b) $x = 0$ is a point of stable equilibrium and $x = \frac{k}{\lambda}$ is a point of unstable equilibrium
   c) $x = 0$ and $x = \frac{k}{\lambda}$ are points of unstable equilibrium

d) There are no points of stable or unstable equilibrium

46. A π meson at rest decays into two photons, which move along x-axis. They are both detected simultaneously after time, $t = 10s$. In an inertial frame moving with velocity $V = 0.6c$ in the direction of one of the photons, the interval between the two detections is (2010 – PH)
   a) 15s
   b) 0s
   c) 10s
   d) 20s
47. A particle of mass m is confined in an infinite potential well:

$$V(x) = \begin{cases} 0 & \text{if} \quad 0 < x < L, \\ \infty & \text{otherwise} \end{cases} \tag{1}$$

   It is subjected to a perturbing potential $V_p = V_o \sin\left(\frac{2\pi x}{L}\right)$ within the well. Let E^1 and E^2 be the corrections to the ground state energy in the first and second order in V_0, respectively. Which of the following are true (2010 – PH)
   a) $E^1 = 0, E^2 < 0$
   b) $E^1 > 0, E^2 = 0$
   c) $E^1 = 0, E^2$ depends in the sign of V_0
   d) $E^1 < 0, E^2 < 0$

I. Common Data Questions

Common Data for Questions 48 and 49

In the presence of a weak magnetic field, atomic hydrogen undergoes the transition :

$$^2P_{\frac{1}{2}} \rightarrow \quad ^1S_{\frac{1}{2}} \tag{2}$$

by the emmision of radiation.

48. The number of lines that are observed in the Zeeman spectrum is (2010 – PH)
   a) 2
   b) 3
   c) 4
   d) 6
49. The spectral line corresponding to the transition

$$^2P_{\frac{1}{2}}\left(m_j = +\frac{1}{2}\right) \rightarrow \quad ^1S_{\frac{1}{2}}\left(m_j = -\frac{1}{2}\right) \tag{3}$$

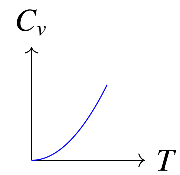
   is observed along the direction of the applied magnetic field. The emitted electromagnetic field is (2010 – PH)
   a) Circularly polarized
   b) Linearly polarized
   c) unpolarized
   d) Not emitted along the magnetic field direction

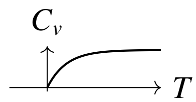
Common Data for Questions 50 and 51

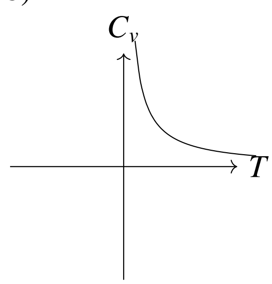
The partition function for a gas of photons is given by

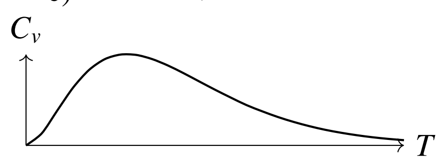
$$\ln Z = \frac{\pi^2 V (k_B T)^3}{45\hbar^3 C^3} \tag{4}$$

50. The specific heat of the photon gas varies with temperature as (2010 – PH)

a) 

b) 

c) 

d) 

51. The pressure of the photon gas is (2010 – PH)
   a) $\frac{\pi^2(k_BT)^3}{15\hbar^3C^3}$
   b) $\frac{\pi^2(k_BT)^4}{8\hbar^3C^3}$
   c) $\frac{\pi^2(k_BT)^4}{45\hbar^3C^3}$
   d) $\frac{\pi(k_BT)^{\frac{3}{2}}}{45\hbar^3C^3}$

II. Linked Answer Questions

Statement for Linked Answer Questions 52 , 53

Consider the propagation of electromagnetic waves in a linear, homogeneous and isotropic material medium with the electric permittivity ϵ and magnetic permeability μ.

52. For a plane wave of angular frequency ω and propagation vector $\mathbf{k}$ propagating in the medium Maxwell's equations reduce to (2010 – PH)
   a) $\mathbf{k}\cdot\mathbf{E} = 0, \mathbf{k}\cdot\mathbf{H}, \mathbf{k}\times\mathbf{E} = \omega\epsilon\mathbf{H}, \mathbf{k}\times\mathbf{H} = -\omega\mu\mathbf{E}$
   b) $\mathbf{k}\cdot\mathbf{E} = 0, \mathbf{k}\cdot\mathbf{H}, \mathbf{k}\times\mathbf{E} = -\omega\epsilon\mathbf{H}, \mathbf{k}\times\mathbf{H} = \omega\mu\mathbf{E}$
   c) $\mathbf{k}\cdot\mathbf{E} = 0, \mathbf{k}\cdot\mathbf{H}, \mathbf{k}\times\mathbf{E} = -\omega\mu\mathbf{H}, \mathbf{k}\times\mathbf{H} = \omega\epsilon\mathbf{E}$
   d) $\mathbf{k}\cdot\mathbf{E} = 0, \mathbf{k}\cdot\mathbf{H}, \mathbf{k}\times\mathbf{E} = \omega\mu\mathbf{H}, \mathbf{k}\times\mathbf{H} = -\omega\epsilon\mathbf{E}$