

- 1) Identify which one is a first-order phase transition?
- A liquid to gas transition at its critical temperature
  - A liquid to gas transition close to its triple point
  - A paramagnetic to ferromagnetic transition in the absence of a magnetic field
  - A metal to superconductor transition in the absence of a magnetic field
- 2) Group I lists some physical phenomena while Group II gives some physical parameters. Match the phenomena with the corresponding parameters:

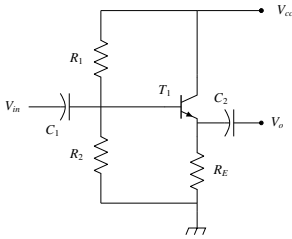
**Group I**

- P. Doppler Broadening  
Q. Natural Broadening  
R. Rotational spectrum  
S. Total internal reflection

**Group II**

1. Moment of inertia  
2. Refractive index  
3. Lifetime of the energy level  
4. Pressure

- a) P-4, Q-3, R-1, S-2  
b) P-3, Q-2, R-1, S-4
- c) P-2, Q-3, R-4, S-1  
d) P-1, Q-4, R-2, S-3
- 3) The separation between the first Stokes and corresponding anti-Stokes lines of the rotational Raman spectrum in terms of the rotational constant, B is
- a) 2B                      b) 4B                      c) 6B                      d) 12B
- 4) A superconducting ring is cooled in the presence of a magnetic field below its critical temperature ( $T_c$ ). The total magnetic flux that passes through the ring is
- a) zero                      b)  $n \frac{h}{2e}$                       c)  $\frac{nh}{4\pi e}$                       d)  $\frac{ne^2}{hc}$
- 5) In a cubic crystal, atoms of mass  $M_1$  lie on one set of planes and atoms of mass  $M_2$  lie on planes interleaved between those of the first set. If  $C$  is the force constant between nearest neighbor planes, the frequency of lattice vibrations for the optical phonon branch with wavevector  $k = 0$  is
- a)  $\sqrt{2C \left( \frac{1}{M_1} + \frac{1}{M_2} \right)}$       b)  $\sqrt{C \left( \frac{1}{2M_1} + \frac{1}{M_2} \right)}$       c)  $\sqrt{C \left( \frac{1}{M_1} + \frac{1}{2M_2} \right)}$       d) 0
- 6) In the quark model, which one of the following represents a proton? This means there are
- a)  $udd$                       b)  $uud$                       c)  $a\bar{b}$                       d)  $c\bar{e}$



7)

The circuit shown above

- a) is a common-emitter amplifier  
b) uses a pop transistor  
c) is an oscillator  
d) has a voltage gain less than one
- 8) Consider a nucleus with  $N$  neutrons and  $Z$  protons. If  $m_n$ ,  $m_p$ , and  $BE$  represent the mass of the neutron, the mass of the proton, and the binding energy of the nucleus respectively, and  $c$  is the velocity of light in free space, the mass of the nucleus is given by
- a)  $Nm_n + Zm_p$   
b)  $Nm_p + Zm_n$   
c)  $Nm_n + Zm_p + \frac{BE}{c^2}$   
d)  $Nm_p + Zm_n + \frac{BE}{c^2}$
- 9) The magnetic field  $(in A m^{-1})$  inside a long solid cylindrical conductor of radius  $a = 0.1$  m is  $\vec{H} = \frac{10^4}{r} \left[ \frac{1}{a^2} \sin(\alpha r) - \frac{r}{a} \cos(\alpha r) \right] \hat{\phi}$  where  $\alpha = \frac{\pi}{2a}$ . What is the total current (in A) in the conductor?
- a)  $\frac{\pi}{2a}$   
b)  $\frac{800}{\pi}$   
c)  $\frac{400}{\pi}$   
d)  $\frac{300}{\pi}$
- 10) Which one of the following current densities,  $\vec{J}$ , can generate the magnetic vector potential  $\vec{A} = (y^2\hat{i} + x^2\hat{j})$ ?
- a)  $\frac{2}{\mu_0} (x\hat{i} + y\hat{j})$   
b)  $-\frac{2}{\mu_0} (\hat{i} + \hat{j})$   
c)  $\frac{2}{\mu_0} (\hat{i} - \hat{j})$   
d)  $\frac{2}{\mu_0} (x\hat{i} - y\hat{j})$
- 11) The value of the integral  $\int_C \frac{e^z}{z^2 - 3z + 2} dz$  where the contour  $C$  is the circle  $|z| = \frac{3}{2}$  is
- a)  $2\pi ie$   
b)  $\pi ie$   
c)  $-2\pi ie$   
d)  $-\pi ie$
- 12) In a non-conducting medium characterized by  $\epsilon = \epsilon_0$ ,  $\mu = \mu_0$ , and conductivity  $\sigma = 0$ , the electric field  $(in V m^{-1})$  is given by  $\vec{E} = 20 \sin [10^8 t - kz] \hat{j}$ . The magnetic field,  $\vec{H} (in A m^{-1})$ , is given by
- a)  $20k \cos [10^8 t - kz] \hat{i}$   
b)  $\frac{20k}{10^8 \mu_0} \sin [10^8 t - kz] \hat{j}$   
c)  $-\frac{20k}{10^8 \mu_0} \sin [10^8 t - kz] \hat{i}$   
d)  $-20k \cos [10^8 t - kz] \hat{j}$