第九章 特殊专题

1. Except for mass, the properties of the muon most closely resemble the properties of the
(A) electron
(B) graviton
(C) photon
(D) pion
(E) proton
解：选（A）。μ子和电子只是同位旋不同。

2. Suppose that ${}^{A}_{Z}X$ decays by natural radioactivity in two stages to ${}^{A-4}_{Z-1}Y$. The two stages would most likely be which of the following?

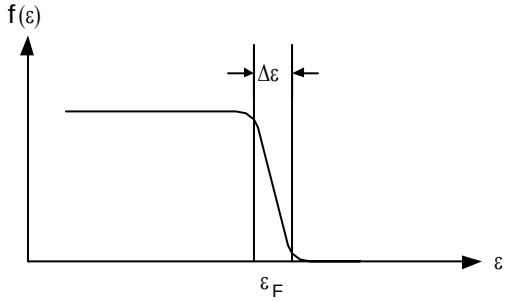
	First Stage	Second Stage
(A)	β^- emission with an anti-neutrino	α emission
(B)	β^- emission	α emission with a neutrino
(C)	β^- emission	γ emission
(D)	Emission of a deuteron	Emission of two neutrons
(E)	α emission	γ emission

解：选（A）。（B）错，α衰变不能出中微子。
antineutrino：反中微子
deuteron：氘核

3. The longest wavelength x-ray that can undergo Bragg diffraction in a crystal for a given family of planes of spacing d is
(A) $\frac{d}{4}$
(B) $\frac{d}{2}$
(C) d
(D) 2d
(E) 4d
解：由 Bragg 公式

$$2d\sin\theta = n\lambda ,$$

当θ=90°时（垂直入射），$\lambda_{\max} = 2d$。选（D）。



4. The Fermi distribution function f(ε) for electrons in a metal is shown above. Which of the following statements is true for this metal?
(A) The Fermi energy ε_F is of the order of kT.
(B) The spread in energies $\Delta\varepsilon$ is independent of the temperature.
(C) The higher the density of elections, the lower the Fermi level.
(D) The distribution results from the assumption that any number of elections can occupy a given quantum state.
(E) Only those elections which ~ kT of the Fermi level can be excited thermally.
解：费米能级ε_F 主要由电子决定。例如绝对零度下

$$\varepsilon_F = \frac{\hbar^2}{2m}\left(3n\pi^2\right)^{\frac{2}{3}},$$

其中 n 为电子浓度。费米能级ε_F比 kT 的量级要大很多，(A)不对。由上述关系，显然 n 越大费米能级ε_F越大，或者说电子浓度越大时，电子需要占据的能态越高，(C)不对。费米能级的由来就是因为任一能级上只能占据有限个粒子，(D)不对。能级的展开$\Delta\varepsilon$由热运动造成，只有费米能级ε_F以下 kT 左右的电子可被激发。选（E）。

5. Solid argon is held together by which of the following bonding mechanism?
(A) Ionic bond only
(B) Covalent bond only
(C) Partly covalent and partly ionic bond
(D) Metallic bond
(E) van der Waals bond

解：氩为惰性气体。满壳层结构，所以不可能是离子键或共价键。惰性气体均为分子晶体，为分子键，或称 van der Waals 键。选(E)。

6. A metal surface emits photoelectrons with maximum energy 1.0 electron volt (eV) when illuminated by 2.0-eV photons. When the surface is illuminated by 4.0-eV photons, the maximum energy of the photoelectrons is

(A) 0 eV
(B) 2.0 eV
(C) 3.0 eV
(D) 4.0 eV
(E) 5.0 eV

解：光电子的最大出射能量等于入射光子能量减去脱出功 W。根据第一次的数据，脱出功 W = 2.0 – 1.0 = 1.0 eV，
则第二次最大能量为 3.0 eV。选（C）。

7. Conduction electrons is an elemental semiconductor such as germanium and silicon can be produced by all of the following means EXCEPT

(A) thermal excitation
(B) optical excitation
(C) electron injection in a junction
(D) doping with a group III element
(E) doping with a group V element

解：锗硅均为四价，所以应引入五价的施主（经常为磷、砷）才能提高电子浓度。选(D)。

8. A necessary and sufficient condition that a force field F be conservative is

(A) $\nabla F = 0$
(B) $\nabla \cdot F = 0$
(C) $\nabla\nabla F = 0$
(D) $\nabla \cdot \nabla F = 0$
(E) $\nabla \times F = 0$

解：保守场的必须满足环量积分为 0，即

$$\oint \mathbf{F} \cdot d\mathbf{l} = 0 。$$

由 Stokes 公式

$$\oint \mathbf{F} \cdot d\mathbf{l} = \iint (\nabla \times \mathbf{F}) \cdot d\mathbf{s}$$

所以 $\nabla \times \mathbf{F} = 0$ 可以保证 $\oint \mathbf{F} \cdot d\mathbf{l} = 0$。选(E)。

9. Which of the following decays is possible in vacuum?

(A) $\pi^+ \to \mu^- + \nu_\mu$

(B) $\pi^- \to \pi^+ + e^- + e^-$

(C) $\pi^0 \to e^- + p$

(D) $p \to n + e^+ + \nu_e$

(E) $n \to p + e^- + \bar{\nu}_e$

解：（D）和（E）均可能发生。但（D）不能在真空中发生，原因是质子为稳定粒子（虽然大统一理论要求质子也能衰变，但是至少现在没有迹象证明这种假设）。自由中子为不稳定粒子，其寿命约为 917 秒。其他几个衰变的正确反应式为：

$$\pi^+ \to \mu^+ + \nu_\mu ,$$

$$\pi^- \to \mu^- + \bar{\nu}_\mu ,$$

$$\pi^0 \to \gamma + \gamma 。$$

选（E）。

10. The electrical conductivity of a relatively pure semiconductor increases with increasing temperature primarily because

(A) the scattering of the charge carriers decreases
(B) the density of the charge carriers increases
(C) the density of the material decreases due to volume expansion
(D) the electric field penetrates further into the material
(E) the lattice vibrations increase in amplitude

解：本征半导体（指未掺杂，没有施主或受主存在）载流子主要为热激发，载流子浓度由温度决定。温度越高，热激发能量越高，载流子浓度越大。具体公式为

$$n = p = \sqrt{N_+ N_-}\, e^{-E_g/2kT} ,$$

其中 E_g 为能隙宽度，N_+、N_-为随温度上升而上升的量。由此可见本征半导体的导电性能随温度升高而增强。选(B)。

11. Electrons of kinetic energy 20 keV are brought to rest by colliding with a solid. Which of the following is true of the shortest wavelength photon that may be emitted?

(A) It has an energy of 20 keV.
(B) It has an energy equal to the ionization energy of an atom in the solid.
(C) It must have a wavelength given by Bragg's law for diffraction.
(D) It is in the infrared range.
(E) It is one of the characteristic x-rays of the solid.

解：当用电子轰击固体时，能量较低时只产生连续光谱；能量高到一定程度，产生的辐射光谱，在连续谱上还叠加由线性光谱（特征辐射）。连续光谱波长连续变化，存在一最短波长，对应于电子动能全部转化为 X 射线能量：

$$h\frac{c}{\lambda_{\min}} = eU \text{。}$$

选(A)。

12. Which of the following quantities is the most suitable to measure in order to determine whether a semiconductor is n-type or p-type?

(A) Resistivity.
(B) Hall coefficient.
(C) Diffusion coefficient.
(D) Carrier lifetime.
(E) Tunneling rate.

解：Hall 系数为

$$R_H = \frac{1}{nq}$$

其中 n 为载流子浓度，q 为载流子所带电量。n 型半导体霍尔系数为负，p 型为正。选（B）。

13. Each of the persons named below is noted for contributions to our knowledge of electricity and magnetism. In which of the following are they placed in chronological order of their scientific contributions?

(A) A. Volta, B. Franklin, J. C. Maxwell, M. Faraday, H. Hertz
(B) B. Franklin, A. Volta, M. Faraday, J. C. Maxwell, H. Hertz
(C) A. Volta, B. Franklin, M. Faraday, H. Hertz, J. C. Maxwell
(D) B. Franklin, M. Faraday, A. Volta, H. Hertz, J. C. Maxwell
(E) M. Faraday, A. Volta, H. Hertz, B. Franklin, J. C. Maxwell

解：Franklin 必为老大，因为此君对电只有感性上的认识，比如雨夜放风筝玩。Volta 做出了第一个实用的电池，也数远古贡献。Faraday，电磁感应定律，十九世纪上半叶。Maxwell 和 Hertz 比较容易混，记住 Maxwell 预言了电磁波的存在，而 Hertz 用实验证实。选（B）。

14. The energies of alpha particles emitted by naturally occurring radioactive nuclei typically range from

(A) 1 eV to 10 eV
(B) 100 eV to 1keV
(C) 10 keV to 100 keV
(D) 1 MeV to 10 MeV
(E) 100 MeV to 1000 MeV

解：早期的核试验中经常用α衰变放出的α粒子去轰击其他物质，可见其能量不会很小。答案选（D）。作为常识应记住这个答案。

15. Which of the following is NOT true for the Debye theory of the specific heat of solids?

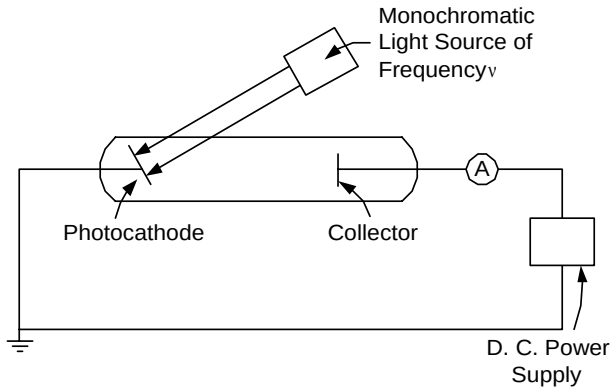
(A) The number of vibrational modes is 3N where N is the number of atoms in the solid.
(B) The vibrational modes are all assumed to have the same frequency.
(C) Well above the Debye temperature, the classical equipartition theorem holds.
(D) The specific heat is proportional to T^3 at low temperatures.
(E) The lattice modes are assumed to correspond to sound waves in the solid.

解：选项（B）为 Einstein 模型的假设，所有振动模式频率相等。而 Debye 模型要求ω从 0 连续变大到一截至频率，即 Debye 频率。答案选（B）。其他几个为 Debye 模型的假设或结论，可以记忆一下。

16. Which of the following statements concerning the electrical conductivities at room temperature of a pure copper sample and a pure silicon sample is NOT true?

(A) The conductivity of the copper sample is many orders of magnitude greater than that of the silicon sample.
(B) If the temperature of the copper sample is increased, its conductivity will decrease.
(C) If the temperature of the silicon sample is increased, its conductivity will increase.
(D) The addition of an impurity in the copper sample always decreases its conductivity.
(E) The addition of an impurity in the silicon sample always decreases its conductivity.

解：对于导体（本题中为铅），随着温度上升电子与离子实的碰撞逐渐剧烈，电子自由程下降，导电性能降低；对于本征半导体(本题中为硅)，温度上升使载流子浓度上升，导电能力升高。而掺杂（施主或受主）往往能使半导体的导电性大大增加。选（E)。



Question 17-18 refer to the following apparatus used to study the photoelectric effect.

In this apparatus, the photocathode and the collector are made from the same material. The potential V of the collector, measured relative to ground, initially zero and is then increased or decreased monotonically. The effect is described by Einstein's photoelectric equation

$$|eV| = h\nu - W$$

17. When the photoelectric equation is satisfied and applicable to this situation, V is the

(A) negative value at which the current stops
(B) negative value at which the current starts
(C) positive value at which the current stops
(D) positive value at which the current starts
(E) voltage induced when the light is on

解：收集极加负电压，排斥电子。只有能量足够高的电子才能被收集。光电子出射方向各异，水平出射最易达到收集极。当收集极恰好接收不到电子时，说明|eV|是出射光电子的最大动能。选（A)。

18. The photoelectric equation is derived under the assumption that

(A) electrons are restricted to orbits of angular momentum $n\hbar$, where n is an integer
(B) electrons are associated with waves of wavelength $\lambda = h/p$, where p is momentum
(C) light is emitted only when electrons jump between orbits
(D) light is absorbed in quanta of energy $E = h\nu$
(E) light behaves like a wave

解：熟知的常识。选（D)。

19. The quantity W in the photoelectric equation is the

(A) energy difference between the two lowest electron orbits in the atoms of the photocathode
(B) total light energy absorbed by the photocathode during the measurement
(C) minimum energy a photon must have in order to be absorbed by the photocathode
(D) minimum energy required to free an electron from its binding to the cathode material
(E) average energy of all electrons in the photocathode

解：W 表示脱出功。选（D)。

20. Which of the following nuclei has the largest binding energy per nucleon? (Consider the most abundant isotope of each element.)

(A) Helium

(B) Carbon
(C) Iron
(D) Uranium
(E) Plutonium

解：核子的平均结合能和原子序数 Z 的关系是：两头小，中间大，在 Z=55 左右达到极值。大家可以思考一下为什么为获取能量，Z 小时为核聚变，Z 大时为核裂变。铁的原子序数 Z=56，平均结合能最大。选（C）。不要误以为铀是核燃料就选择（D）。

21. The Hall effect is used in solid-state physics to measure
(A) ratio of charge to mass
(B) magnetic susceptibility
(C) the sign of the charge carriers
(D) the width of the gap between the conduction and valence bands
(E) Fermi energy

解：Hall 系数

$$R_H = \frac{1}{nq},$$

其中 n 为载流子浓度，q 为载流子电量。当载流子带负电时，霍尔系数为负；相反则为正。选（C）。此外 Hall 系数还可用来测量载流子浓度。

22. One feature common to both the Debye theory and the Einstein theory of the specific heat of a crystal composed of N identical atoms is that the
(A) average energy of each atom is 3kT
(B) vibrational energy of the crystal is equivalent to the energy of 3N
(C) crystal is assumed to be continuous for all elastic waves
(D) speed of the longitudinal elastic waves is less than the speed of the transverse elastic waves
(E) upper cutoff frequency of the elastic waves is the same

解：Einstein 和 Debye 模型的共同点是：晶格振动等效为 3N 个谐振子（因为自由度为 3N）；不同点是：Einstein 很粗糙地假设所有谐振子频率相同，Debye 假设ω从 0 增大到一个截至频率ω_D。答案选（B）。

23. The mean kinetic energy of electrons in metals at room temperature is usually many times the thermal energy kT. Which of the following can best be used to explain this fact?
(A) the energy-time uncertainty relation
(B) The Pauli exclusion principle
(C) The degeneracy of the energy levels
(D) The Born approximation
(E) The wave particle duality

解：Pauli 不相容原理限制一个能级上可允许的电子数目，从而迫使电子向更高能级上排布。使平均动能往往远大于 kT。选（B）。

24. When a narrow beam of monoenergetic electrons impinges on the surface of a single metal crystal at an angle of 30 degrees with the plane of the surface, first-order reflection is observed. If the spacing of the reflecting crystal planes is known from x-ray measurements to be 3 angstroms, the speed of the electrons is most nearly
(A) 1.4×10^{-4} m/s
(B) 2.4 m/s
(C) 5.0×10^{3} m/s
(D) 2.4×10^{6} m/s
(E) 4.5×10^{9} m/s

解：由 Bragg 公式

$$2d\sin\theta = n\lambda,$$

本题中 n = 1，θ = 30°。所以速度为

$$v = \frac{P}{m} = \frac{h}{\lambda m} = \frac{h}{2d\lambda\sin\theta}。$$

代入数字计算，选(D)。

25. ${}^{13}_{5}B \rightarrow {}^{7}_{3}Li + {}^{4}_{2}He + Q$

An unstable boron nucleus decays at rest into a lithium nucleus and a helium nuclues.with total kinetic energy Q as shown above. Which of the following is true?
(A) Each decay product has half the kinetic energy.
(B) Each decay product has the same speed
(C) The decay products tend to go in the same direction.
(D) The lithium nucleus has more momentum than

the helium nucleus.

(E) The helium nuclueus has more kinetic energy than the lithium nucleus.

解：反应前后动量守恒。由于反应前重子静止，动量为 0。所以反应后锂原子和氦原子动量大小相等，方向相反。质量大的动能小。选（B）。

26. Which of the following properties of a nucleus can be determined from studies of the hyperfine structure of optical spectra

(A) Spin
(B) Mass defect
(C) Binding energy
(D) Charge radius
(E) Atomic number

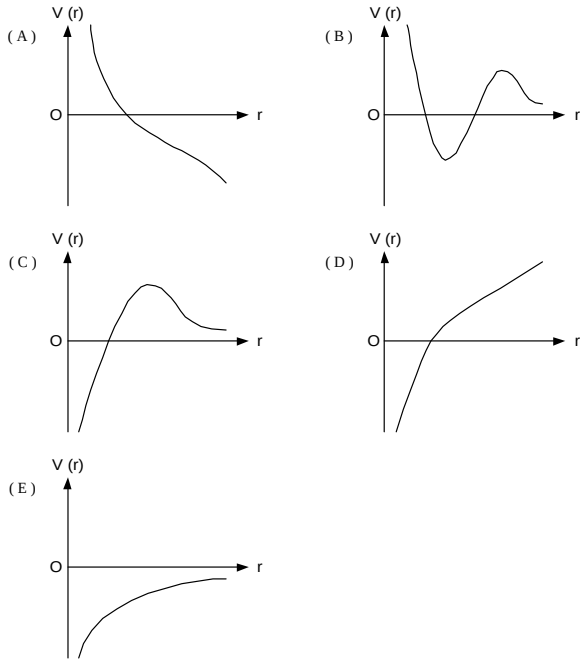
解：产生超精细结构的原因是，核外电子的总角动量与核的自旋耦合，组成新的总角动量。选（A）。

27. Why is β^- decay more common than β^+ decay among naturally occurring radioactive elements?

(A) The binding of positions in nuclei is greater than that of electrons.
(B) Electrons are more easily excited by γ rays than are positrons.
(C) The binding energy per nucleon is approximately constant for heavy nuclei.
(D) Positrons cannot exist in ordinary matter.
(E) Alpha (α) decay leaves nuclei neutron-rich.

解：β 衰变本质上是中子与质子间的转变。丰中子核发生β^-衰变，使一个中子变为质子，增加一个核电荷数。相反贫中子核发生β^+衰变，质子变为中子。由于自然界中丰中子核占多数，另外α衰变使核中的中子过剩，倾向于发生β^-衰变。选（E）。

28. A meson consists of a quark and an antiquark bound by the strong interaction potential V(r), where r is the distance between them. Which of the following curves most closely represents this potential?



解：V(r)满足：⑴ $r \to \infty$ 时，$V(r) \to 0$。由此排除（A）、（D）。⑵ r 比较大时为吸引力， r 小时为排斥力，阻碍夸克与反夸克无限靠近。所以 r 较小时 V(r)为正，而且当 $r \to 0$ 时，$V(r) \to \infty$ 。排除（C）、（E）。选（B）。

29. The particle decay $\Lambda \to p + \pi^-$ must be a weak interaction because

(A) the π^- is a lepton.
(B) the Λ has spin zero
(C) no neutrino is produced in the decay
(D) it does not conserve angular momentum
(E) it does not conserve strangeness

解：核子和π 介子等强子统称为普通强子。普通强子和光子、电子、μ子、τ子、中微子以及他们的反粒子和起来称为普通粒子。奇异子，例如Λ^0，K^0，$K^\pm$，Σ^0，$\Sigma^\pm$ 等，有确定的奇异数 S。在强相互作用中和电磁相互作用中 S 守恒，在弱相互作用中 S 不守恒。本题中 Λ的奇异数为 S = –1，而 p、π^-，为普通粒子，S 不守恒。选（E）。

30. A necessary and sufficient condition that a force field F be conservative is

(A) $\nabla F = 0$
(B) $\nabla \cdot F = 0$
(C) $\nabla\nabla F = 0$

(D) $\nabla\cdot\nabla F=0$
(E) $\nabla\times F=0$

解：$F=\nabla\varphi\Leftrightarrow\nabla\times F=\nabla\times\nabla\varphi=0$，有势场即无旋场。选（E）。

31. A metal surface emits photoelectrons with maximum energy 1.0 electron volts (eV) when illuminated by 2.0-eV photons. When the surface is illuminated by 4.0-eV photons, the maximum energy of the photoelectrons is
(A) 0eV
(B) 2.0eV
(C) 3.0eV
(D) 4.0eV
(E) 5.0eV
解：根据 Einstein 的光电理论，金属的脱出功

$$A=h\nu-E_k=1.0\text{eV}，$$

当光子能量为 4.0eV 时，

$$E_k=h\nu-A=3.0\text{eV}。$$

选（C）。

32. A beam of particles is incident on a thin target of thickness t. If the cross section per nucleus for a scattering of the particles by the nuclei of the of the target is σ, and the number of nuclei per unit volume is n, the fraction of particles scattered is
(A) σ / nt
(B) σt
(C) ntσ
(D) nt / σ
(E) nσ
解：核反应截面的物理含义是表示一个入射粒子与靶上一个靶核发生核反应的几率，具有面积的量纲。定义为

$$\sigma=\frac{n_r}{n_iNt}。$$

因此发生核反应的几率

$$\frac{n_r}{n_i}=nt\sigma。$$

选（C）。

33. From a knowledge of the sizes of atoms and nuclei, which of the following is the most reasonable approximation for the ratio of the density of nuclear matter to the density of water?
(A) 1
(B) 10^3
(C) 10^6
(D) 10^{10}
(E) 10^{14}
解：原子核的质量 $m\sim10^{-27}$ kg，线度 $r\sim10^{-15}$ m，水的密度 $\rho_0=10^3$ kg/m^3，因此估算数量级有

$$\frac{\rho}{\rho_0}=\frac{m}{\frac{4}{3}\pi r^3\rho_0}\approx\frac{10^{-27}}{10^{-45}\cdot10^3}\sim10^{-14}。$$

选（E）。

34. What are the changes in the mass number A and atomic number Z of a numbers that undergoes electron capture?
(A) A is unchanged; Z decreases by 2.
(B) A is unchanged; Z decreases by 1.
(C) A is unchanged; Z increases by 1.
(D) A decreases by 2; Z increases by 1.
(E) A decreases by 4; Z decreases by 2.
解：电子吸收的一般反应式为

$${}^A_ZX+e\rightarrow{}^A_{Z-1}Y。$$

选（B）。注意，一些主要的核反应衰变形式例如α衰变、β衰变（β^-衰变、β^+衰变和轨道电子俘获 EC）、γ衰变的反应式应该掌握。

35. A hypothetical boson has a nonzero value for all of the following quantities. Which quantity is the same for the boson and its antiparticle? (Ignore the existence of weak interactions.)
(A) Strangeness
(B) Charm
(C) Intrinsic parity
(D) Magnetic moment
(E) Electric charge
解：选（C）。关于正反粒子，它们的质量、寿命、

自旋磁矩的 g 因子完全相同。由于由一对正反粒子组成的纯中性体系具有确定的宇称，推出正反 Fermion 有相反的内禀宇称，正反 Boson 有相同的内禀宇称。请记住该结论。

36. Which of the following could NOT be expected to contribute substantially to the resistivity of a metal crystal as its temperature approaches absolute zero

(A) Phonons
(B) Dislocations
(C) Atomic impurities
(D) Grain boundaries
(E) Lattice vacancies

解：金属晶体中存在的杂质与缺陷等因素将破坏周期势场，引起电子的散射，对金属的电阻是有贡献的。而平均声子数随温度的下降指数衰减，在低温极限下，只有晶格的低频振动即长声学波才对散射有贡献。且随着温度的降低，有贡献的晶格振动模式不断减少，可以忽略。选（A）。

37. According to the nuclear shell model, the spin and parity, respectively, of lithium-7 (Z = 3, N = 4) should be

(A) 0, even
(B) 1/2, even
(C) 1, odd
(D) 3/2, even
(E) 3/2, odd

解：根据原子核的强自旋轨道耦合壳层模型，Li–7 是奇偶核，未配对的核子是第三个质子，处于 $1p_{3/2}$ 态，因此自旋为奇。选（E）。

38. The lines in the characteristic emission spectra of elements in galaxies at great distance from Earth are shifted to longer wavelengths relative to those observed from these elements on Earth. The principal cause of this shift in wavelength is commonly thought to be

(A) scattering of the shorter wavelength compoments out of the light from the galaxies, similar to the effect observed in the reddening of the light from the Sun when it is near the horizon
(B) multiple scattering of the photons during their trip to Earth
(C) an increase in the velocity of the photons during their trip to Earth.
(D) a gravitational effect as the radiation escapes
(E) a Doppler effect caused by the galaxies reddening from the Earth

解：遥远星系发出的光谱谱线都是红移的，这是运动光源的 Doppler 效应引起的。根据 Hubble 膨胀宇宙的观点，所有的星系都在离开地球而膨胀。选（E）。

39. In the nuclear reaction $\alpha + {}^{40}Ar \to p + X$, the nucleus X is

(A) ${}^{41}K$
(B) ${}^{42}K$
(C) ${}^{43}K$
(D) ${}^{44}K$
(E) ${}^{41}Ar$

解：由反应的质量数和电荷数守恒计算可得，

$$A_X = 4 + 40 - 1 = 43,$$

$$Z_X = 2 + 18 - 1 = 19。$$

选（C）。

40. A radioactive nucleus A has a mean life of 10 seconds. The nucleus decays into its daughter B. The mean life of B is 10 years. Starting with 10^{22} nuclei A at t = 0, the rate of decay of B at t = 1 year is most nearly

(A) 10^{22} per year
(B) 10^{21} per year
(C) 10^{20} per year
(D) 10^{19} per year
(E) zero

解：由于$\tau_A << t < \tau_B$，近似可以认为在 t 时刻内所有的 A 核都衰变成了 B 核，而大部分 B 核还未衰变。$n_B \sim 10^{22}$。根据原子核的衰变规律

$$\frac{dn}{dt} = -\frac{n}{\tau} \approx \frac{10^{22}}{10} = 10^{21} / \text{year}。$$

选（B）。

41. Which of the following reactions or decays is allowed by the laws of nature?

(A) $p \to \pi^+ + \pi^0$

(B) $\pi^- + p \to K^+ + \Sigma^-$

(C) $\pi^- \to e^- + \gamma$

(D) $p \to \Sigma^+ + \pi^0$

(E) $p + p \to n + p + \pi^+ + \pi^- + \pi^0$

解：(A) 反应前后重子数不守恒，(C) 反应前后轻子数不守恒，(D) 反应前后奇异数不守恒（注意强相互作用中末态奇异粒子必须协同产生，才能满足奇异数守恒），(E) 反应前后电荷数不守恒。选 (B)。

42. For a simple inorganic lattice such as NaCl, first-order Bragg scattering of x-rays might reasonably take place at close to 30° for x-rays of wavelength most nearly equal to

(A) 0.3 A
(B) 3.0 A
(C) 30 A
(D) 300 A
(E) 3000 A

解：典型晶体的晶格常数 d~A。根据 Bragg 衍射条件，

$$2d\sin\theta = n\lambda ,$$

n = 1，θ = 30°时有

$$\lambda = d 。$$

因此λ ~ A。选 (B)。

43. Which of the following is NOT characteristic of any superconductor?

(A) The resistivity vanishes below the transition temperature.
(B) A sufficiently large magnetic field can destroy the superconducting state.
(C) A gap exists in the allowable energy levels of the material.
(D) A magnetic field is excluded from the superconductor.
(E) The superconductor is paramagnetic.

解：超导体的基本特性有：在临界温度以下，超导体呈现零电阻性和完全抗磁性。超导态可以被大于临界磁场的外加磁场破坏。超导体一般不是铁磁体。选 (C)。

44. If only the volume and surface energies are considered, which of the following expressions best approximates the binding energy of a large nucleus containing A nucleons (a and b are positive constants)?

(A) $aA - bA^{-1/3}$

(B) $aA - bA^{-2/3}$

(C) $aA - bA^{2/3}$

(D) $aA + bA^{1/3}$

(E) $aA + bA^{2/3}$

解：体积能正比于核子个数 A，处于表面的核子能量比内部的要低，而表面的总原子数正比于 $A^{2/3}$，因此总能量应具有

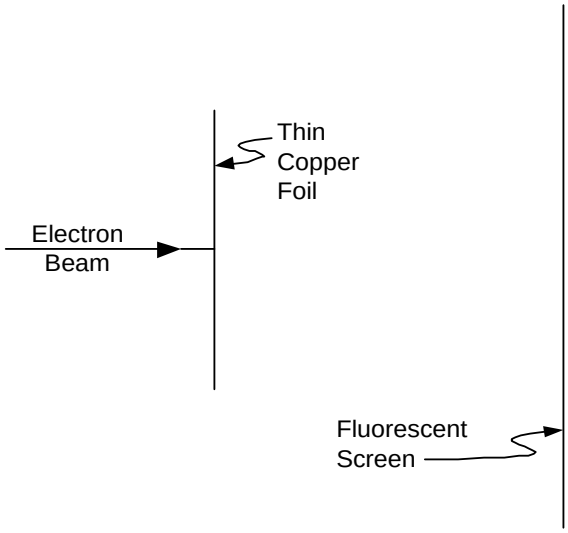
$$aA - bA^{2/3}$$

的形式。选 (C)。

45. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2}
(B) 10^{-5}
(C) 10^{-8}
(D) 10^{-11}
(E) 10^{-14}

解：作为常识，原子半径的数量极为 10^{-10} 米，而原子核半径为 10^{-15} 米。选 (B)。



46. In order to observe a ring diffraction pattern on the screen shown above, which of the following conditions must be met?

(A) The electron beam must be polarized.
(B) The electron beam must be approximately monoenergetic.
(C) The copper foil must be a single crystal specimen.
(D) The copper foil must be uniform thickness.
(E) The electron beam must strike the foil at normal incidence.

解：晶体结构的实验衍射方法主要有以下几种。

Laue 法：用一束连续波长的 X 射线或中子辐射束照射固定的单晶上。衍射图像是一组亮斑点。

旋转晶体法：单晶围绕一个固定轴在单色 X 射线束中旋转，改变 θ 角使不同原子面满足布拉格方程。当θ 角满足条件时，入射 X 射线束就从衍射晶面反射。

Debye 粉末法：单色 X 射线束照射在细粉末样品或细晶粒多晶样品上，微晶取向接近连续变化。衍射图像是一系列同心圆环。

本题类似于第三种情况，电子束能量单一化，就保证其波长近似相等。选（B）。选项（D）、（E）并不是必要的。

47. Materials that are good electrical conductors also tend to be good thermal conductors because

(A) they have highly elastic lattice structures
(B) they have energy gaps between the allowed electron energy bands
(C) impurities aid both processes
(D) surface states are important in both processes
(E) conduction electrons contribute to both processes

解：导体可看作由固定于晶格上的离子实和自由传导电子组成。传导电子做近自由运动，联系着导体的不同部分，在导电的同时还承担着热传导的重任。电子在温度较高的地方通过与离子实碰撞，获得较高的能量；在温度较低的地方，把一部分能量交给离子实。定量的说，金属导体的电导率为

$$\sigma = \frac{ne^2\tau}{m},$$

而热导率为

$$\kappa = \frac{1}{3}Cvl = \frac{1}{3}nc\overline{v^2}\tau,$$

其中 τ 为弛豫时间，c 为平均一个粒子的热容。Frantz 定律更直接地表现了二者间的关系

$$\frac{\kappa}{\sigma T} = \frac{3}{2}\left(\frac{k_B}{e}\right)^2 = 1.11\times10^{-8}\ \mathrm{W\cdot\Omega/K^2}。$$

选（E）。

48. Which of the following statements about the lattice vibrations of a crystal of NaCl is NOT true?

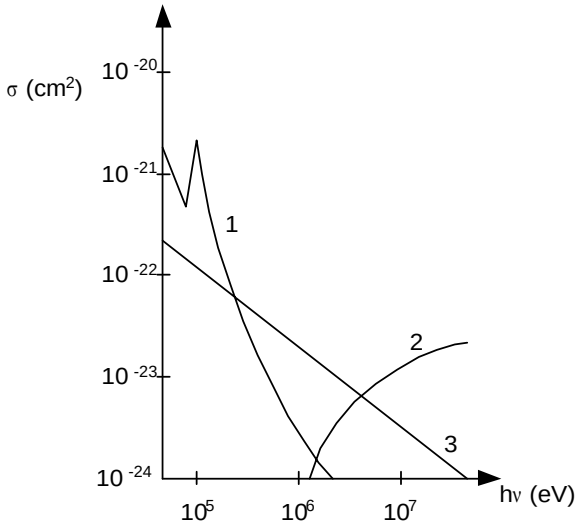
(A) The acoustic modes for long wavelengths correspond to elastic waves.
(B) In the acoustic mode, the Na and Cl ions tend to move in the same direction.
(C) For each value of the propagation vector k, there is one transverse acoustic mode and one longitudinal acoustic mode.
(D) In the optical mode, the Na and Cl ions move in opposite directions.
(E) The optical mode has an oscillatory dipole moment.

解：一个纵波两个横波。选（C）。

49. Which of the following would NOT be expected to contribute substantially to the resistivity of a metal crystal as its temperature approaches absolute zero?

(A) Phonons
(B) Dislocations
(C) Atomic impurities

(D) Grain boundaries
(E) Lattice vacancies
解：声子比热~T^3，当 T 趋于 0 时趋于 0。选（A）。



50. The figure above shows the photon interaction cross section for lead in the energy range where the Compton, photoelectric, and pair production processes all play a role. What is the correct identification of these cross sections?
(A) 1=photoelectric, 2=Compton, 3=pair production
(B) 1=photoelectric, 2=pair production, 3=Compton
(C) 1=Compton, 2=pair production, 3=photoelectric
(D) 1=Compton, 2=photoelectric, 3=pair production
(E) 1=pair production, 2=photoelectric, 3=Compton
解：光电效应有一个截止频率，只有 1 能反映出“截止”的特性（不光滑），因此 1 是光电效应。Pair production 是光子产生正负电子对的过程，显然能量越高越能产生电子对，即σ随 hν增大而增大，2 是 pair production。选（B）