

第八节 实验方法

1. The resolving time of a counter is 2.5×10^{-6} second and the dead time of the recording device is 3×10^{-4} second. If the recording number of incident particles is $N = 5 \times 10^3$ per second, the number of recorded particles is closest to

- (A) 1×10^3 pulses s^{-1}
 (B) 2×10^3 pulses s^{-1}
 (C) 3×10^3 pulses s^{-1}
 (D) 4×10^3 pulses s^{-1}
 (E) 5×10^3 pulses s^{-1}

解：计数器的分辨时间很短，由于受到记录设备的限制，最大计数频率为

$$f = \frac{1}{3 \times 10^{-4}} = 3.3 \times 10^3 \text{ pulse} \cdot s^{-1},$$

低于散射粒子的出现频率。选 (C)。

2. The initial intensity I_0 of a beam of photons of a certain energy is reduced to $\frac{1}{2}I_0$ as the beam traverses a thin sheet of lead of thickness d . If the beam traverses a sheet of lead of thickness $3d$, its intensity is reduced to

- (A) $\frac{1}{3}I_0$
 (B) $\frac{1}{4}I_0$
 (C) $\frac{1}{6}I_0$
 (D) $\frac{1}{8}I_0$
 (E) $\frac{1}{9}I_0$

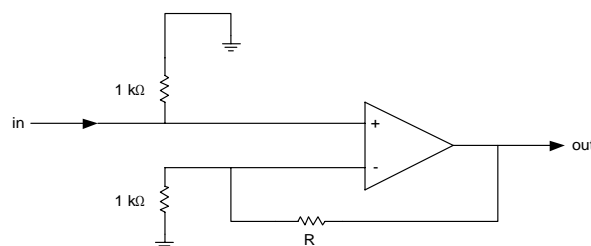
解：由散射公式

$$I = I_0 e^{-ks}$$

得

$$I(3d) = I_0 e^{-3kd} = I_0 (e^{-kd})^3 = \left(\frac{1}{2}\right)^3 I_0 = \frac{1}{8} I_0.$$

选(D)。



3. For which of the following values of resistor R will the gain of the operational amplifier shown above be closest to 100?

- (A) 10 kΩ
 (B) 20 kΩ
 (C) 100 kΩ
 (D) 200 kΩ
 (E) 500 kΩ

解：理想放大器放大倍数为 ∞ ，为保证输出电压为有限值，要求

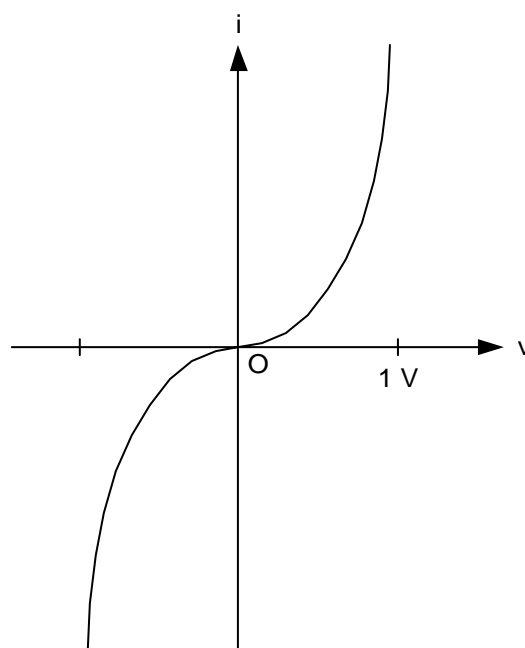
$$V_+ = V_- ,$$

$$V_{in} = V_+ = V_- = \frac{1}{1+R} V_{out}.$$

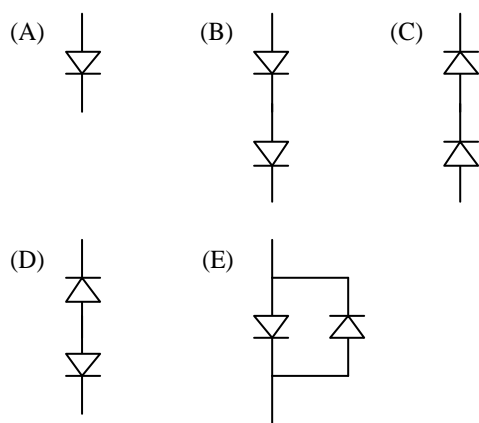
放大倍数为

$$A = \frac{V_{out}}{V_{in}} = 1 + R.$$

选 (C)。



4. Which of the following circuits will have the $v-i$ characteristic shown above? (All the diodes are silicon.)

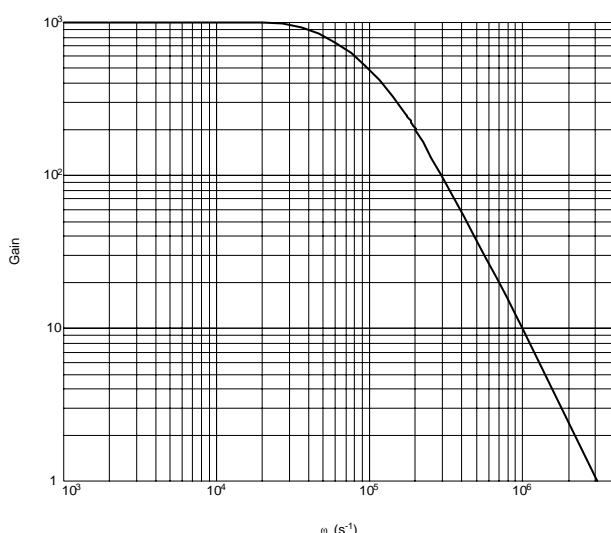


解：答案选 (E)。 (A)、(B)、(C) 等同于普通的二极管，而答案(E)中两个二极管反接，几乎不导通。

5. The time a laser light beam takes to travel from the Earth to the Moon and back is most nearly

- (A) 2 microseconds
- (B) 2 milliseconds
- (C) 2 seconds
- (D) 2 minutes
- (E) 2 hours

解：地月间距平均为 38 万公里，真空中光速为 30 万公里每秒，均为基本常识。选 (C)。



6. The gain of an amplifier is plotted *versus* angular frequency ω in the diagram above. If K and a are positive constants, the frequency dependence of the gain near $\omega=3 \times 10^{-5} \text{ second}^{-1}$ is most accurately

expressed by

- (A) $Ke^{-a\omega}$
- (B) $K\omega^2$
- (C) $K\omega$
- (D) $K\omega^{-1}$
- (E) $K\omega^{-2}$

解：在 $\omega=3 \times 10^{-5} \text{ second}^{-1}$ 处，约为斜率为-2 的直线。注意到此图为双对数曲线，所以

$$\ln \text{gain} = -2 \ln \omega + c,$$

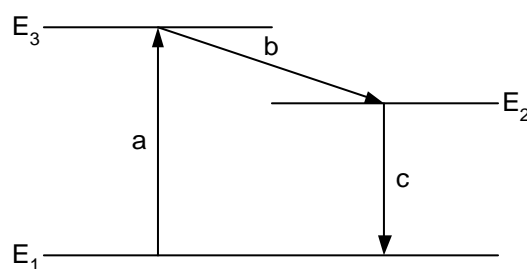
$$\text{gain} = e^c \omega^{-2} = k \omega^{-2}.$$

选(E)。

7. A proton beam is incident on a scatterer 0.1 centimeter thick. The scatterer contains 10^{20} target nuclei per cubic centimeter. In passing through the scatterer, one proton per incident million is scattered. The scattering cross section is

- (A) 10^{-29} cm^2
- (B) 10^{-27} cm^2
- (C) 10^{-25} cm^2
- (D) 10^{-23} cm^2
- (E) 10^{-21} cm^2

解：散射几率 $P=1/10^6$ ，为无量纲量。散射截面 σ 的量纲为米²，靶核浓度 n 量纲为米⁻³，厚度 l 量纲为米。所以为凑得一个无量纲数，显然公式为 $P = n \cdot l \cdot \sigma$ （其实公式本身很简单，这里只是举一个量纲分析的例子，不一定很恰当。由于 P 为无量纲数，似乎 P 可以等于 $(n \cdot l \cdot \sigma)^n$ ，这时需要用物理思想判断 n 的取值）。选 (C)。



8. The diagram above shows the levels and transitions of a ruby laser. All of the following statements about the laser are correct EXCEPT:

- (A) The laser works because of population inversion.
- (B) E_2 is the energy of a metastable state.
- (C) Transition a involves absorption of radiation.
- (D) Transition b involves stimulated emission.
- (E) The laser must be optically pumped by radiation of frequency $f = \frac{E_3 - E_1}{h}$.

解：受激辐射指在满足频率要求的外来光子的激励下高能级的原子向低能级跃迁。而众所周知，激光器中粒子通过受激吸收从基态 E_0 跃迁到激发态 E_3 上，粒子从激发态 E_3 通过碰撞以无辐射跃迁的方式转移到亚稳态 E_2 。由于 E_2 能级寿命较长，在 E_2 上粒子积累，实现粒子数反转。选 (D)。

9. Measurement of the degree of a vacuum by a thermocouple gauge is based primarily on the

- (A) decrease in thermal conductivity of a gas with decreasing pressure
- (B) increase in thermal conductivity of a gas with decreasing pressure
- (C) decrease in the electrical conductivity of a gas with decreasing pressure
- (D) increase in the electrical conductivity of a gas with decreasing pressure
- (E) pressure dependence of the Thomson

解：热电偶真空计简介：它是通常用来测量低真空的真空计，可测范围为 $10^{-1} \sim 10^{-3}$ Torr。其中有一根细金属丝以恒定功率加热到约 200 。由于气体热导率随压强变化（压强越低热导率越小），所以热丝的温度成为压强的函数，经过校准定标后，可以由测量热丝温度的热电偶的指示测定压强。选 (A)。

10. Of the following quantities, measurement of which would normally be the most practical way to determine the magnitude of a magnetic field B of approximately 1 tesla (weber per meter squared)?

- (A) Deflection of a laser beam
- (B) Curvature of the path of a charged particle of known velocity

(C) Torque produced on a permanent magnet

(D) Eddy-current heating of a moving metallic object

(E) Hall voltage across a small probe

解：由题意，应当是易于操作的。(A)、(B)、(C)、(D) 的效应都很难在实验上操作，而且不能测量 1T 这样量级的磁场。Hall 效应

$$V_H = R_H \frac{IB}{d},$$

其中 R_H 为 Hall 系数。一般 I 的数量级在 A，d 的数量级在 cm，Hall 电势差的数量级在 T 左右。选 (E)。

11. A 10-bit analog-to-digit converter converts voltages to digital form with an accuracy of approximately 1 part in

- (A) 10
- (B) 10^2
- (C) 10^3
- (D) 10^4
- (E) 10^{10}

解：数模转换卡中采用二进制计数，n 位转换卡的转换精度为（最大量程为 V_0 ）

$$\Delta V = \frac{1}{2^n} V_0,$$

对 10 位的卡，

$$\frac{\Delta V}{V_0} = \frac{1}{2^{10}} \sim 1000。$$

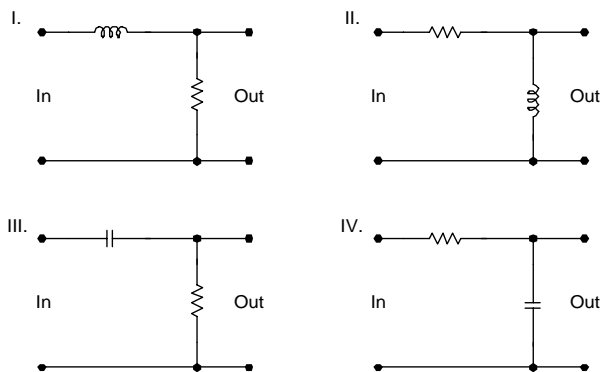
选 (C)。

12. A certain experiment requires the maintenance of a vacuum of 10^{-2} atmospheres in a closed-off system. Which of the following is the simplest pumping arrangement that will meet this requirement?

- (A) A mechanical pump only
- (B) A mechanical pump and a oil-diffusion pump only
- (C) A mechanical pump, a oil-diffusion pump, and a dry-ice trap
- (D) A mechanical pump, a oil-diffusion pump, and a liquid-air trap
- (E) A mechanical pump, a oil-diffusion pump, and a liquid-helium trap

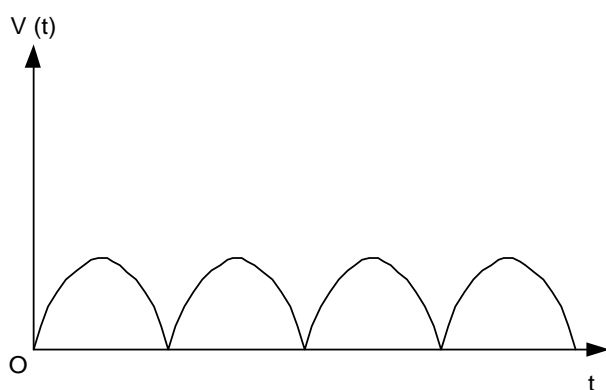
解：一般真空获得中，机械泵的极限压强约为 10^{-3} Torr (10^{-5} atm)，扩散泵的极限压强约为 10^{-6} Torr (10^{-8} atm)。它们都属于外排型真空泵。
选 (A)。

13. Which of the following circuits are high-pass filters?

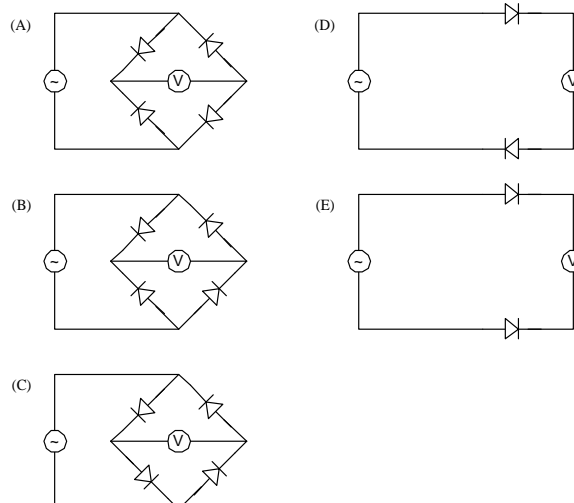


- (A) I and II
(B) I and III
(C) I and IV
(D) II and III
(E) II and IV

解：在滤波电路中电感的作用是通低频，阻高频；电容的作用是通高频，阻低频。电阻则没有频率特性。II 和 III 的电路当频率很高时，输出信号近似等于输入。选 (D)。



14. Which of the following circuits employing diodes constitutes a full-wave rectifier in which a sinusoidal input signal is converted to an output $V(t)$, as shown in the diagram above?



解：(B) (E) 不形成通路，(C) 是短路，(D) 是半波整流电路，只有 (A) 是全波整流电路。选 (A)。

15. Which of the following measure the charge of an electron independently of its mass?

- (A) Millikan oil-drop experiment
(B) Thomson experiment
(C) Franck-Hertz experiment
(D) Cyclotron resonance
(E) Compton effect

解：(A) 是一个宏观实验，带电体是油滴，所以在测电荷电量时显然不涉及电子的质量。选 (A)。

16. All of the following pure liquids or mixtures at 1 atmosphere pressure are correctly paired with the temperatures of the constant temperature baths they may be used to produce EXCEPT

- (A) helium, 4K
(B) nitrogen, 77K
(C) hydrogen, 90K
(D) dry ice and acetone, 195K
(E) ice and water, 273K

解：单质 H_2 的沸点为 $20.28K < 90K$ 。选 (C)。

17. High-energy gamma rays can be produced by back-scattering laser light from a beam of very high-energy electrons. This method depends on the properties of

- (A) Rayleigh scattering
(B) Thompson scattering

- (C) Bragg scattering
(D) Raman scattering
(E) Compton scattering

解：为光子和电子间的碰撞，应属于 Compton 散射。只是常见的 Compton 散射是光子碰撞静止电子，因此光子能量减少，波长变长。本题中光子与高能电子碰撞，获得能量。选 (E)。

18. An experimenter measures the counting rate from a radioactive source to be 10,150 counts in 100 minutes. Without changing any of the conditions, the experimenter counts for one minute. There is a probability of about 15 percent that the number of counts recorded will be fewer than

- (A) 50
(B) 70
(C) 90
(D) 100
(E) 110

解：Poisson 分布。计数平均值为 N 时，某次特定

的计数落在 $(N - \sqrt{N}, N + \sqrt{N})$ 区间里的几率为

$68\% \approx 70\%$ ，所以单次计数 $< N - \sqrt{N}$ 的几率为

$$\frac{1 - 70\%}{2} = 15\%。$$

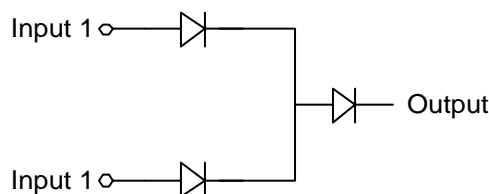
对于本题，1 分钟计数的最可几值为

$$\frac{10150}{100} \approx 100，$$

因此计数小于

$$100 - \sqrt{100} = 90$$

的几率约为 15%。选 (C)。



19. If logical 0 is 0 volts and logical 1 is +1 volt, the circuit shown above is a logic circuit commonly known as

- (A) an OR gate
(B) an AND gate
(C) a 2-bit adder
(D) a flip-flop
(E) a fanout

解：真值表如下

input1	input2	output
0	0	0
1	0	1
0	1	1
1	1	1

或门。答案选 (A)。

20. An experimenter measures 9934 counts during one hour from a radioactive sample. From this number the counting rate of the sample can be estimated with a standard deviation of most nearly

- (A) 100
(B) 200
(C) 300
(D) 400
(E) 500

解：Poisson 分布。标准差

$$\sqrt{9934} \approx 100。$$

选 (A)。

21. A charged particle traverses a proportional counter. About 10^4 times as many electrons are collected as are formed by the particle in traversing the counter. This is the result of

- (A) stimulated emission
(B) photoelectron production

- (C) ionization by collisions
(D) magnetic resonance
(E) the Auger effect

解：一个带电粒子通过正比计数器的时候，打中计数器里的气体原子，将其电离。电离后的正负粒子在电场作用下加速，进一步电离更多的原子，形成一个放电脉冲。选 (C)。

22. A technique would most likely increase the signal-to-noise ratio of a photomultiplier tube is to

- (A) operate the tube at a lower temperature
(B) operate the tube at higher voltage per dynode than usually specified
(C) use a radioactive source to saturate the noise level
(D) use a retarding potential on the first dynode
(E) use a photocathode of lower work function

解：降温是通常的方法。选 (A)。

23. Which of the following is NOT an attribute of a typical photomultiplier tube?

- (A) It operates by producing an avalanche of ions in a gas.
(B) It can produce electrical output pulses less than 10^{-6} second long.
(C) It can produce 10^3 or more electrons per incident photon.
(D) It is affected by a ambient magnetic fields greater than a few gauss.
(E) It detects photoelectrons ejected by light from a photocathode.

解：光电倍增管里要抽真空，不能有气体，(A) 不对。选 (A)。

24. Work hardening of a solid is a result of the

- (A) tangling of dislocation lines
(B) annealing of point defects
(C) breaking of superfluous bonds
(D) generation of Frenkel pairs
(E) softening of the phonon spectrum

解：Work hardening：加工硬化，指金属由于发生了很大的形变从而超过其弹性限度后，将其硬化的过程。它的主要原因是金属中的缺陷错位在压力下聚集相互影响。选 (A)。

25. Which of the following is most commonly used to provide a stable reference voltage of about 12 volts in an electronic circuit?

- (A) Zener diode
(B) Tunnel diode
(C) Thynstor
(D) Vanstor
(E) Field-effect transistor

解：Zener 二极管可以用来稳压。选 (A)。

26. Which of the following is most useful for measuring temperatures of about 3,000K?

- (A) Optical pyrometer
(B) Carbon resistor
(C) Gas-bulb thermometer
(D) Mercury thermometer
(E) Thermocouple

解：Optical pyrometer 叫光学高温计，当然可用来测高温。选 (A)。

27. A counter near a long-lived radioactive source measures an average of 100 counts per minute. The probability that more than 110 counts will be recorded in a given one-minute interval is most nearly?

- (A) zero
(B) 0.001
(C) 0.025
(D) 0.15
(E) 0.5

解：Poisson 分布，15%。见 18 题。选 (D)。