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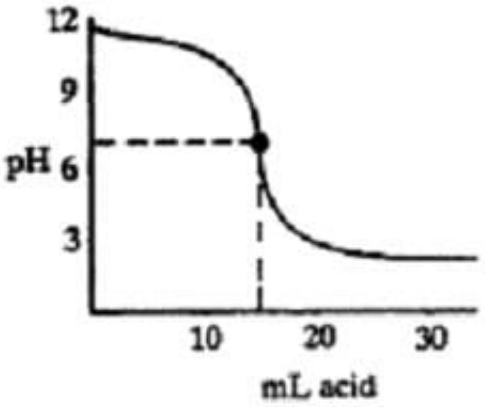
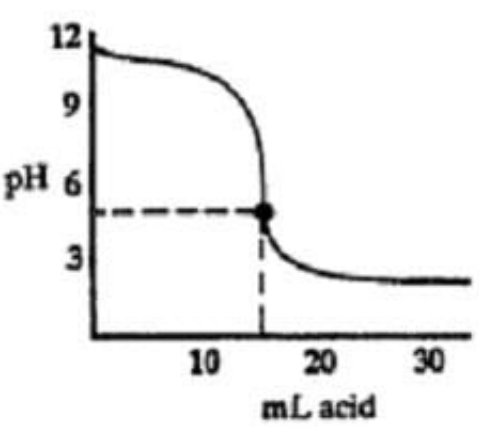
QUESTION 1

Which titration curve would be produced by titrating 25 mL of a 0.1 N weak base with a 0.1 N strong acid?

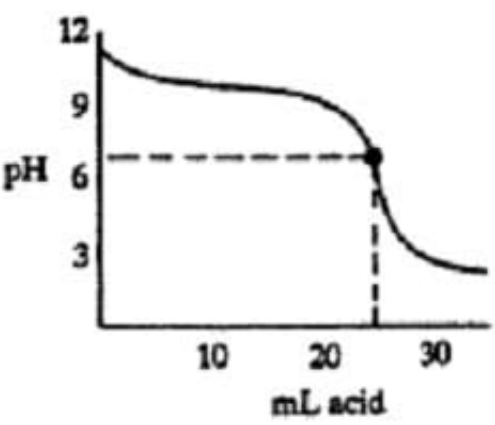
A.


12
9
pH 6
3
10
20
30
mL acid

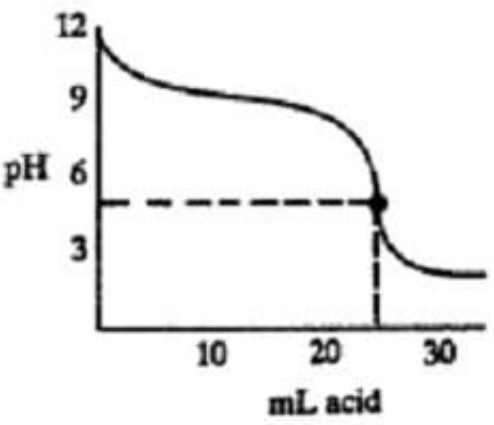
B.


12
9
pH 6
3
10
20
30
mL acid

C.


12
9
pH 6
3
10
20
30
mL acid

D.


12
9
pH 6
3
10
20
30
mL acid

A. Option A

B. Option B

C. Option C

D. Option D

Correct Answer: D

In this question you are asked about the titration of a weak base with a strong acid. The points marked by the dotted lines in each graph are the equivalence points. These are the points at which the acid has been totally neutralized by the added base. To decide which of these graphs is accurate, there are two things you need to know. First, you need to decide how much of a weak base is required to neutralize a strong acid. Second, you must know what the pH will be after the acid has been completely neutralized. First, let\\'s consider the amount of strong acid needed to neutralize a weak base. The question tells you that both the weak base and the strong acid are 0.1 N. Since the weak base is only partially dissociated, the actual hydroxide ion concentration of the base will be considerably lower than the hydrogen ion concentration of the strong acid. For this reason, it may seem likely that the volume of acid that you would have to add to the base to bring about neutralization would be lower than the volume of the base you started with. In choices A and B, only 15 mL of acid are added to bring 25 mL of base to the equivalence point. However, the problem with this line of reasoning is that as soon as the small amount of free hydroxide in the basic solution has been neutralized, more of the base will dissociate and there will be more hydroxide. As you continue to add acid, eventually all of the base will dissociate. Thus, you\\'ll end up having to add enough acid to neutralize all of the hydroxide in the base, just as if it were a strong base. Since the number of equivalents are equal in this case due to the equal normalities, the neutralization of 25 mL of weak base will require a full 25 mL of strong acid and that means that you can eliminate choices A and B. Next, you\\'ll have to decide what the pH of the neutralized solution will be. When the base has been completely neutralized, a solution of salt water remains. But the cation, since it comes from a weak base, has a strong tendency to recombine with hydroxide ions from the water. The anion, since it comes from a strong acid, remains completely dissociated. This means that the process of hydrolysis takes place; the cation combines with the hydroxide from water molecules while the resulting hydrogen ions remain free in solution. Thus, a neutralized solution formed from a weak base and a strong acid will be slightly acidic and choice D is correct.

QUESTION 2

Walking down a street late at night, an adult male pedestrian notices a young female on the ground, not moving. The female is on the opposite side of the street. Crossing the street, the pedestrian notices that the young woman appears both much wealthier than he is and is of a different ethnicity. Seeing nobody else present, the pedestrian renders aid.

According to the bystander effect, which of the following would change how the pedestrian reacts?

A. The person requiring aid appearing to be of a lower socioeconomic class rather than a higher one

B. The presence of another group of people one block up the street

C. The person requiring aid appearing to be the same ethnicity rather than a different one

D. The presence of one other person who is already approaching the girl

Correct Answer: D

The bystander effect indicates that people are less likely to take action when there are other people present and it seems as though the other people will take charge of the situation or will take direct action. Here, if another person is already heading towards the girl, the pedestrian may assume someone else is going to render aid, and will just move on, rather than rendering aid himself. Thus (D) is the correct answer. A, C: The bystander effect concerns itself with the presence of other people. B: While this choice indicates the presence of other people, their distance from the situation

makes it less likely that the pedestrian will assume that others are helping.

QUESTION 3

Ink jet printers produce high resolution output, at a lower cost than laser printers, by generating charged ink droplets which are then deflected onto a sheet of paper by an electric field. Each droplet deflected by the field strikes the paper and forms a tiny dot of ink. While a typical printed letter requires about 100 drops, an ink jet printer is able to produce drops at a rate of 100,000 per second.

$\times 10^{-10}$

The essential elements of the ink jet printer head are shown in Figure 1. The drop generator produces the ink droplets, each with a mass of approximately 1.2 kg and a diameter of approximately 30 m. The drops then enter a

$\times 10^{-13}$

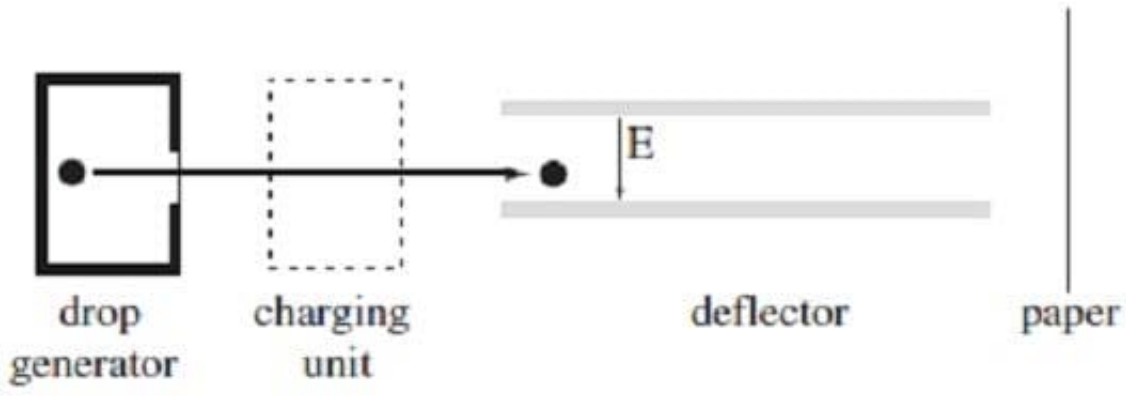
highly precise charging unit which controls the charge q on each droplet to within 2%, with typical charges for drops generated by various ink jet printers ranging from ?.0 C to ?.0 C. The charged droplets are

$\times 10^{6}$

subsequently passed through the deflecting plates between which a variable electric field is generated. The electronically controlled electric field between the plates is typically varied over a range from 1.0 N/C to 5.4 N/C,

$$(\text{Note: } B = \frac{\mu_o i}{2\pi r} \; F = Eq, \text{ and } k = 8.99 \times 10^9 \; N \cdot m^2/C^2)$$

and is used to aim the ink droplet at the paper. .



An ink jet printer deflects a particular ink droplet by 1.5 mm in the region of the deflector. Which of the following is a possible value of the work done on the droplet?

A. No work

B. $4.5 \times$ ____ J (10^{-13})

C. $4.3 \times$ ____ J (10^{-10})

D. $8.1 \times$ ____ J (10^{-8})

A. Option A

B. Option B

C. Option C

D. Option D

Correct Answer: C

To deflect an ink droplet, the deflector must do work on the drop. The formula for calculating work is . To answer the question we must calculate the force generated by the electric field of the deflector. Because the electric field is uniform, the electric force will also be uniform. The electric force is related to electric field by the formula F = Eq.So, to calculate the work done by the drop, we can use the formula W = E X q X d. (The field and the displacement are parallel, so = 0?and cos = 1.) The question gives the distance as 1.5 mm and the passage gives a range of values for the field generated by the deflector and for the charge on the oil droplet. Because the answer choices are fairly spread out, we can calculate using average values for the drop charge and field strength.

$$(W = Fd\cos\theta)$$

$$W_{avg} = -E_{avg}\, q_{avg}\, d$$

$$W_{avg} = -(3.2 \times 10^{6}\mathrm{N/C})(-6.5 \times 10^{-14}\mathrm{C})(1.5 \times 10^{-3}\mathrm{m}$$

$$W_{avg} = -(3.2 \times -6.5 \times 1.5)(10^{-11})$$

$$W_{avg} \approx 30 \times 10^{-11} = 3 \times 10^{-10}\,\mathrm{J}$$

Choice A is incorrect because work is done by the electric field. If a magnetic field were involved, no work would be done because the force is always perpendicular to the direction of movement.

QUESTION 4

An automatic external defibrillator (AED) is simply a series of capacitors used to store a very large charge, which is then discharged through the patient\\'s chest in a short time. If the capacitor in an AED is fully charged and the AED is no longer connected to the power source, what will happen to the energy stored in the AED if the dielectric (k = 1.5) is removed?

A. increase by a factor of 1.5

B. increase by a factor of 2.25

C. decrease by a factor of 1.5

D. decrease by a factor of v1.5

Correct Answer: A

Explanation: The MCAT will expect you to know a handful of equations for capacitors. The three needed to solve this question are:

C = eoA / d

C = Q / V

PE = (?QV

According to the first equation, we see that if the dielectric is removed, capacitance will decrease by a factor of 1.5. According to the second equation, we see that a decreased capacitance can either be the result of a change in Q or a change in V. In this question, the AED is no longer connected to the battery, so there is no source of additional charges. Thus, Q will remain the same and V will increase by a factor of 1.5. Finally, by the third equation we see that if V is increased by a factor of 1.5, the potential energy will increase by a factor of 1.5. Thus, choice (A) is the correct answer.

QUESTION 5

Hemophilia is a genetically inherited disease that causes the synthesis of an abnormal clotting factor. As a result, hemophiliacs bleed excessively from the slightest injury. The figure below is a partial pedigree for the hemophilia trait in Queen Victoria\\'s descendants. The pedigree indicates no history of hemophilia for either parent prior to the F1 generation.

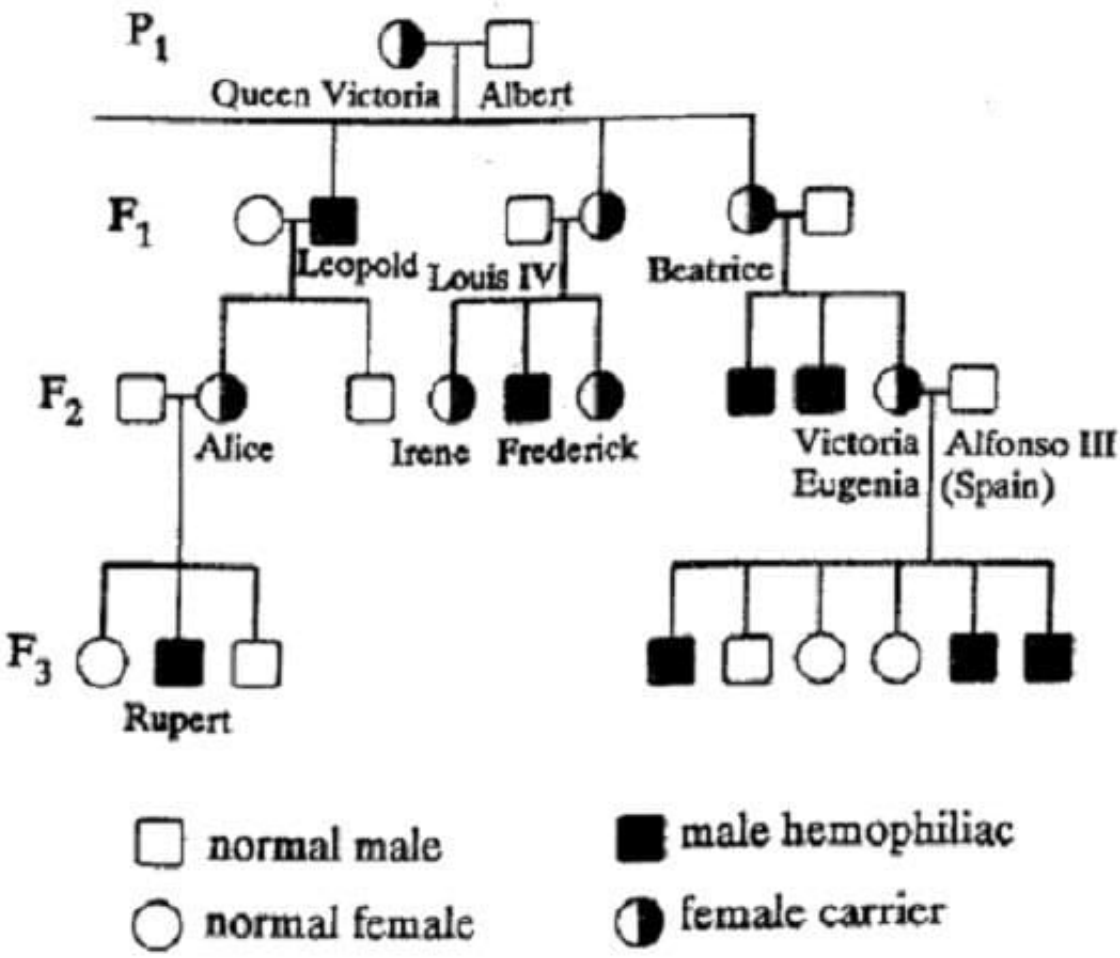


Figure 1

Theoretically, what percentage of Victoria Eugenia\\'s sons should have been hemophiliacs?

A. 25%

B. 33%

C. 50%

D. 75%

Correct Answer: C

If you look at the pedigree, you\\'ll see that Victoria Eugenia had four sons, three of which were hemophiliacs. So, 75% of her sons turned out to be hemophiliacs. You know that these sons inherited the disease from their mother, as opposed to their father, Alfonso III of Spain, because their mother was a carrier of the disease, as can be seen on the pedigree, and their father was normal. Okay, so 75% was the actual percent, but the question asks you to determine the theoretical probability that Victoria Eugenia\\'s sons would be hemophiliacs. So, what you have to do is just work out the cross between a carrier female and a normal male and look at the results. And, if you do that, you\\'ll find that theoretically, 50% of Victoria Eugenia\\'s daughters should have been carriers, 50% should have been normal; and 50% of her sons should have been hemophiliacs, 50% should have been normal. So the probability that Victoria Eugenia\\'s

sons would have been hemophiliacs is 50%.