

The logo for Next Step Test Prep is centered in a blue square. It features the words "Next" and "Step" stacked vertically in a large, white, sans-serif font. Below them, the words "TEST PREP" are written in a smaller, white, all-caps, sans-serif font. The background of the slide is dark blue with a repeating pattern of small white plus signs, and a white inverted triangle shape is at the bottom.

Next
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Chemistry review

Today's Info Session

- ▶ Introduction
- ▶ Discussion of titrations
- ▶ Titrations with amino acid
- ▶ Chem practice passage
- ▶ How Can Next Step Help?
- ▶ Questions?

Next
Step
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MCAT
Medical College
Admission Test

WHAT IS YOUR NEXT STEP?

Introduction

Next
Step
TEST PREP

Hi, I'm Phil!

- ▶ **MCAT Content writer**
 - ▶ **Tutored and taught for 9+ years**
 - ▶ **Attended University of Nebraska Medical Center as an MD/PhD student.**
- ✓ **Next Step is a team of test prep and educational experts committed to excellence.**



Who Is Next Step?

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TEST PREP

- Began in 2009 as a tutoring company
- Focus on graduate admissions tests only
- Team of educational experts
- First company to have materials built from ground up for 2015 MCAT format
- Now the first company to have new 2018 MCAT Interface

✓ We never stop improving our materials!



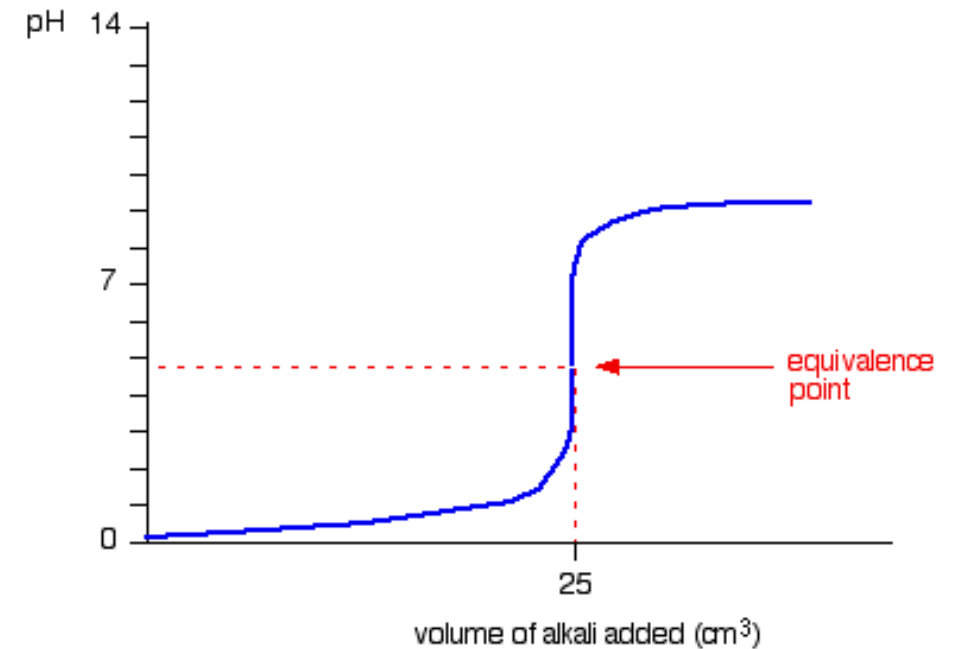
Titration

Used to determine the concentration of an acid or base!

At equivalence point, we have one acid molecule for every base molecule

$$M_a V_a = M_b V_b$$

If I started with 5 mL of an HCl solution and titrated with 1M of a Base as shown, what was my acid concentration?



Was it a strong or weak base?

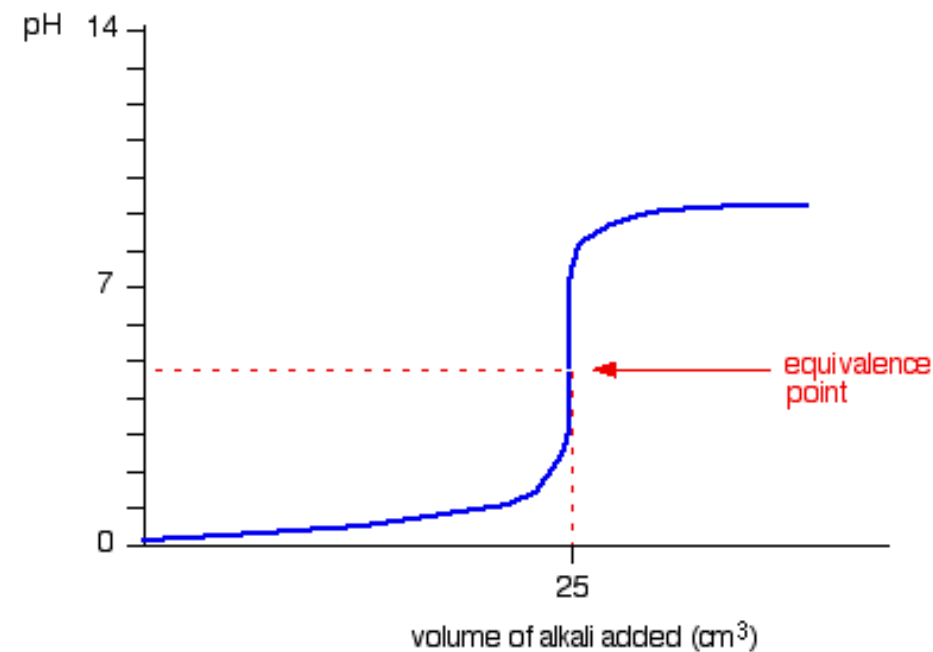
Titration

Where on the graph will I find the most HCl?



What happens at the $\frac{1}{2}$ eq pt?

$$\text{pH} = \text{pKa} + \log \left(\frac{\text{Conjugate base}}{\text{Acid}} \right)$$



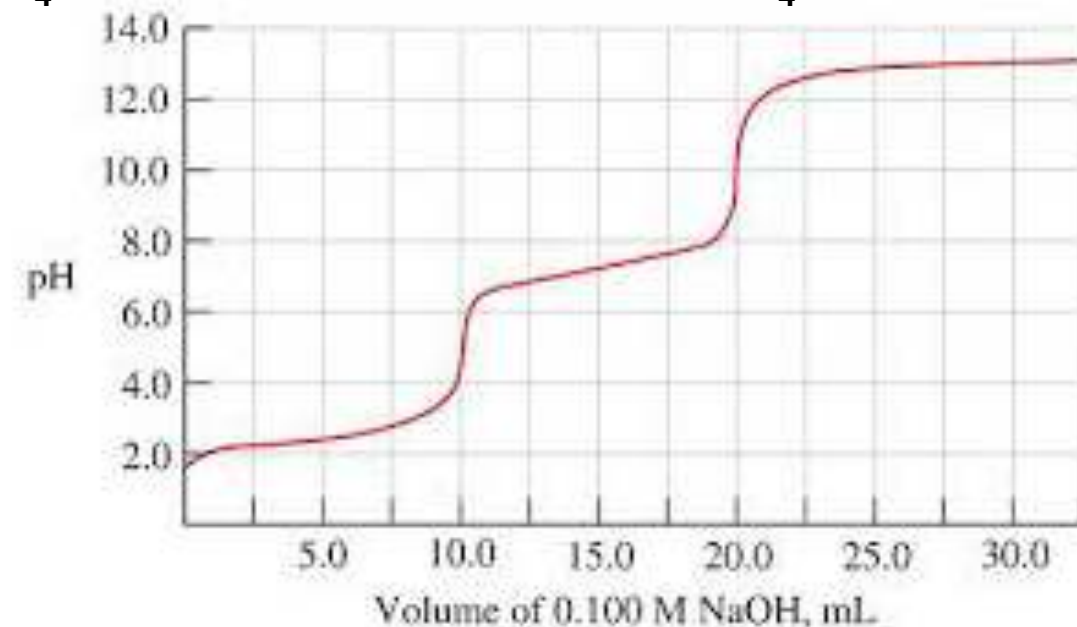
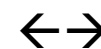
Titration

What can you tell me about my acid?

If I started with 5 mL of my acid, what is its concentration?

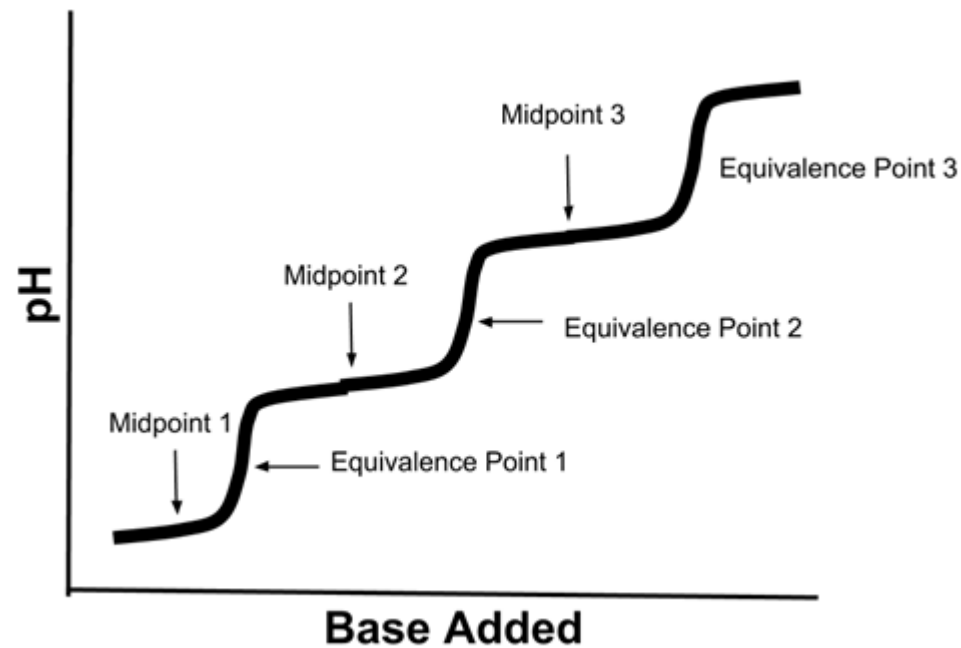
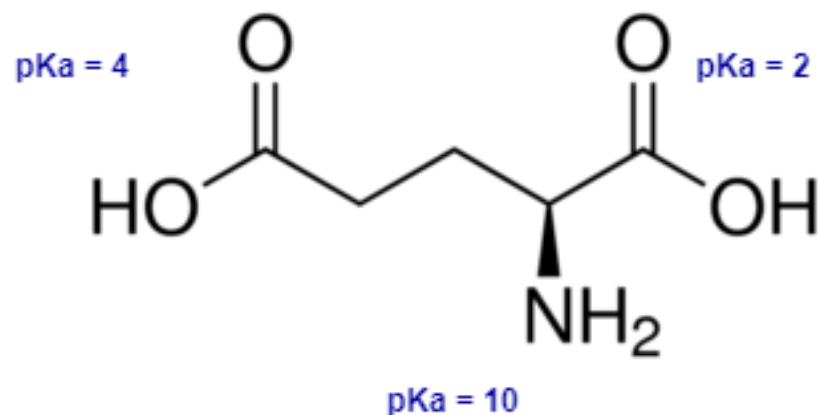
Where on this graph will I find the most HSO_4^- ?

What are the pKas?



Titration

What is the pH where this molecule has 0 charge overall?



Practice Passage

Titration is used to determine the concentration of a particular compound in a solution. An acid-base titration starts with a known volume of the desired acid or base. An indicator that will change color near the equivalence point of the titration is added to the solution. Then, an acid or base, typically a strong acid or base, is added dropwise to the initial solution until the indicator changes color. Acid-base titration can be used to generate titration curves, an example of which is shown in Figure 1

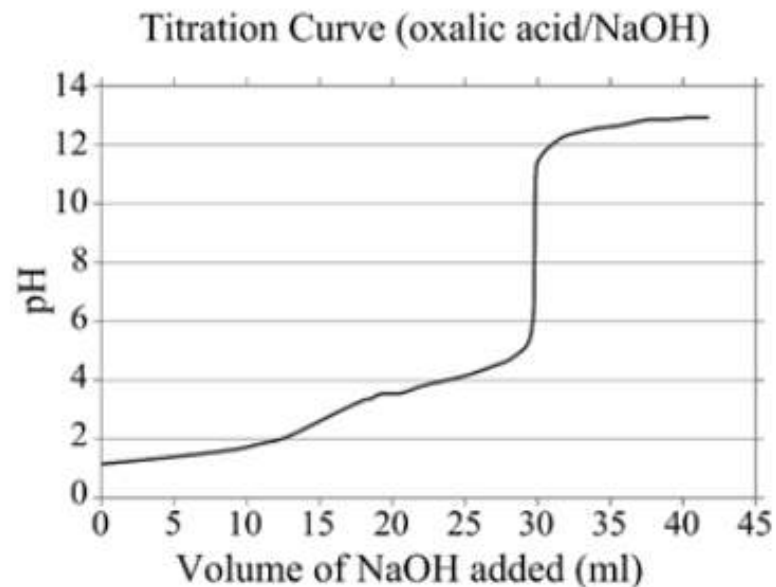


Figure 1 Titration of oxalic acid with NaOH

In order to keep track of titrations, specialized indicators are used. A drop of indicator solution is added to the titration at the beginning; the endpoint has been reached when the color changes. Selected pH indicators are listed in Table 1.

| Indicator | Range of Color Change | Acidic Color | Basic Color |
|-------------------|-----------------------|--------------|-------------|
| Methyl violet | 0.0-1.6 | Yellow | Violet |
| Bromophenol blue | 3.0-4.6 | Yellow | Blue |
| Methyl red | 4.4-6.3 | Red | Yellow |
| Bromothymol blue | 6.0-7.6 | Yellow | Blue |
| Naphtholphthalein | 7.3-8.7 | Red | Green |
| Phenolphthalein | 8.3-10.0 | Colorless | Pink |

Table 1 Color Change and pH Range for Common Indicators

Isothermal Titration Calorimetry (ITC) uses the principles of calorimetry to determine binding parameters of a biomolecular binding reaction. The experimental setup of ITC is shown in Figure 2. Initially, water is added to the reference cell and a solution containing the protein or biomolecule of interest is added to the sample cell. The heat source heats each solution to the desired experimental temperature. The reference cell is held at a constant temperature throughout the experiment. Then, the ligand is added to the sample cell in small aliquots of known volume and concentration.

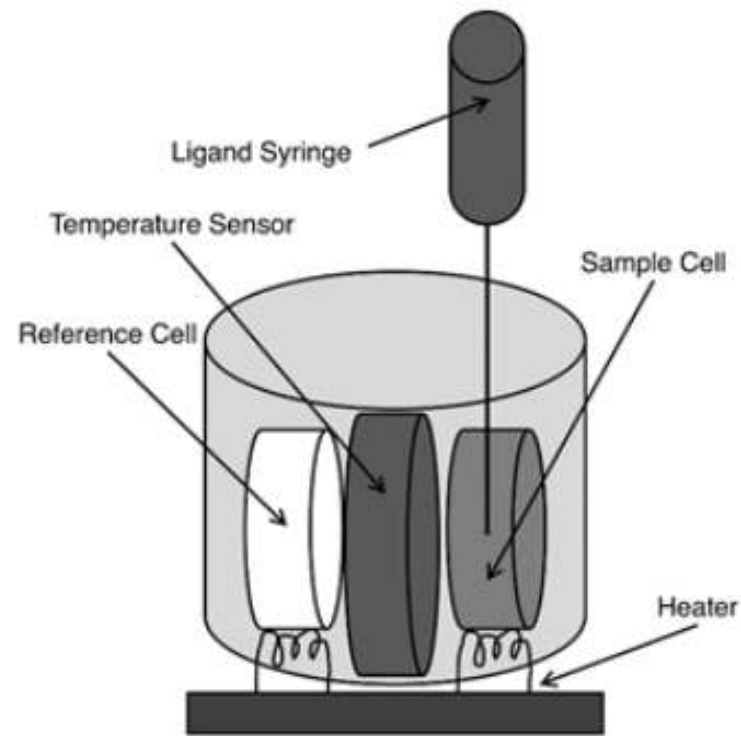
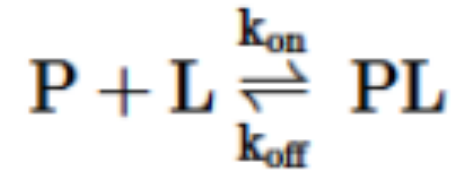


Figure 2 Isothermal Titration Calorimetry device

As the ligand is added to the sample solution, it binds to the protein or biomolecule in the solution. When the binding reaction occurs, heat is transferred between the reaction and the surrounding solution. The sensor detects the change in temperature between the sample cell and the reference cell and signals to the heater to adjust the heat transfer accordingly to return the sample cell to the desired experimental temperature. The heat transfer is measured throughout the reaction, and these measurements are used to determine the thermodynamic parameters and binding parameters for the reaction.

Questions

A scientist uses ITC to determine the thermodynamic parameters of the exergonic reaction between a protein (P) and its ligand (L).



Measurements reveal that as the ligand is added to the sample cell, the rate of heat transfer from the heater to the sample cell is increased. Which of the following must be true of the forward reaction?

- I. $\Delta H > 0$
- II. $\Delta S > 0$
- III. $\Delta G > 0$

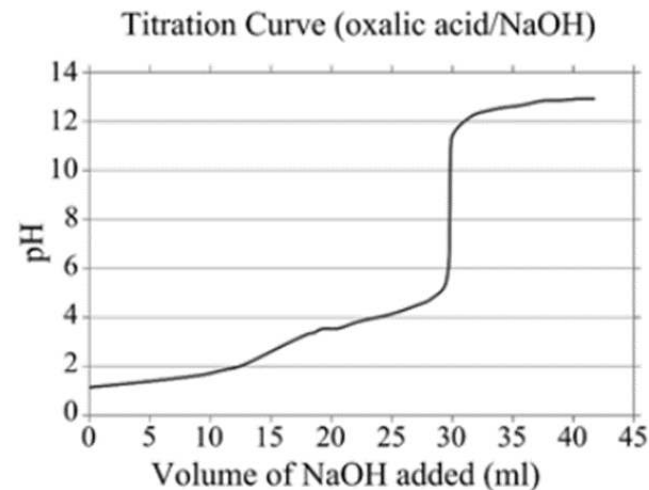
- A. I only
- B. I and II only
- C. II and III only
- D. I, II, and III

Questions

A researcher is titrating an oxalic acid solution with NaOH as shown in Figure 1. Which indicator is the most appropriate for the titration shown in Figure 1?

- A. Bromophenol blue
- B. Methyl Red
- C. Bromothymol blue
- D. Naphtholphthalein

| Indicator | Range of Color Change | Acidic Color | Basic Color |
|-------------------|-----------------------|--------------|-------------|
| Methyl violet | 0.0-1.6 | Yellow | Violet |
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Questions

The thermodynamic parameters of a binding reaction were determined using isothermal titration calorimetry with the temperature held at 37°C. What is the ΔG for the reaction at 37°C?

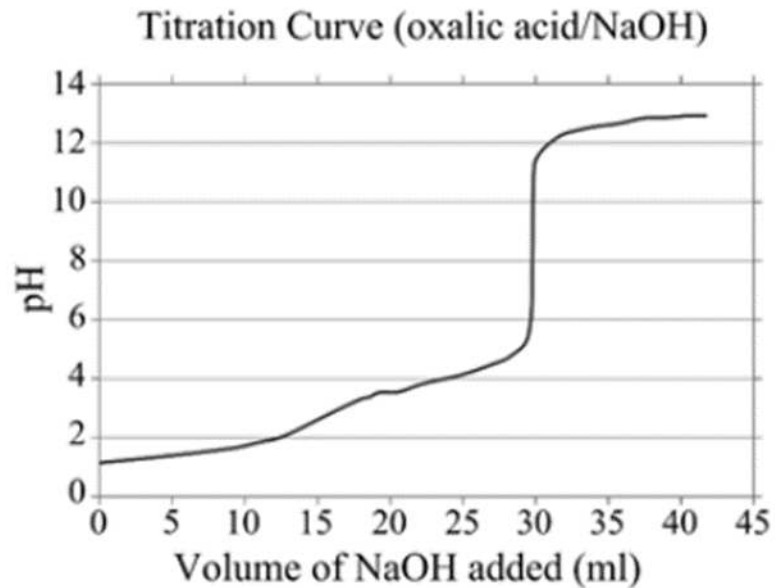
- A. -1570 kJ/mol
- B. -230 kJ/mol
- C. 230 kJ/mol
- D. 1570 kJ/mol

| | |
|-----------------------|------------------------|
| ΔH | -220 kJ/mol |
| ΔS | 36.6 J/mol·K |
| K_D | 3.4×10^{-9} M |
| Protein Concentration | 0.05 μ M |
| pH | 7.4 |

Questions

Based on the titration shown in Figure 1, what is the pK_a of oxalic acid?

- A. 1.5
- B. 3.5
- C. 8.0
- D. 13.0



Questions

Nitrous acid and its conjugate base are combined in a 1 to 5 ratio to form a 100 mL buffer solution. If the K_a of nitrous acid is approximately 4.0×10^{-4} , what is the pH of the buffer solution?

A. 2.7

$$\text{pH} = \text{pKa} + \log (\text{Cb}/\text{A})$$

B. 3.4

$$\text{pKa} = - \log (\text{Ka})$$

C. 4.1

D. 6.5

Questions

For which of the following titrations would methyl red be an accurate indicator?

- A. Strong acid/weak base
- B. Strong base/weak acid
- C. Strong acid/strong base
- D. Weak acid/weak base

| Indicator | Range of Color Change | Acidic Color | Basic Color |
|-------------------|-----------------------|--------------|-------------|
| Methyl violet | 0.0-1.6 | Yellow | Violet |
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Q&A

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4.7



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Additional Free Resources

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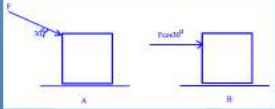
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Question of the Day

Two people push a box along a frictional surface. One pushes the box at an angle of 30° to horizontal with force F while the other pushes the box horizontally with force $F\cos 30^\circ$. Which person does the most work?

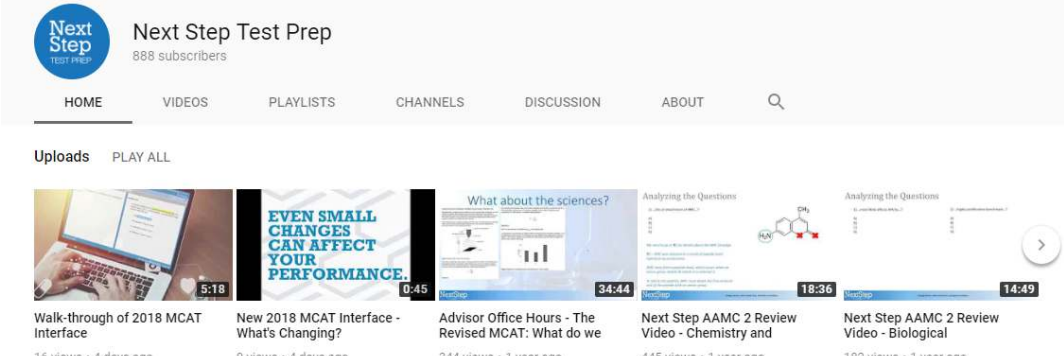


A) Person A
B) Person B
C) Person A and B do equal amounts of work
D) cannot be determined

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New 2018 MCAT In

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- New highlighting features
- New strikethrough features
- New keyboard shortcuts
- New Navigation/Review Screens

Next Step is ready. Are you?

Medical College Admission Test - Clara Gillan Time Remaining: 01:21:34 18 of 59

Highlight Strikethrough

Remove Highlight

Pause

Figure 1 Eosinophil activation as measured by percent of CD69-positive cells after 3 and 12 hours of co-culture (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Next, researchers aimed to assess the effect of NK co-culture on eosinophil degranulation. After 3 and 12 hours of co-culture, samples were centrifuged at 1500 rpm, and ECP levels were measured in the supernatants (Figure 2). No ECP was detected in supernatant culture of NK cells alone.

Question 18

Which of the statements below is supported by the experimental results, as shown in Figures 1 and 2?

- A. The duration of Eos co-culture with NK cells directly and linearly correlates to the amount of ECP found in the supernatant after centrifugation.
- B. Cells cultured with a 1:1 NK-to-Eos ratio displayed statistically similar levels of activation to cells cultured with a 5:1 NK-to-Eos ratio, as measured by CD69 expression.
- C. NK co-culture stimulates Eos activation while inhibiting degranulation.
- D. Co-culture with NK cells significantly increased Eos degranulation in all groups, as compared to Eos cells cultured alone.

Periodic Table Review Screen

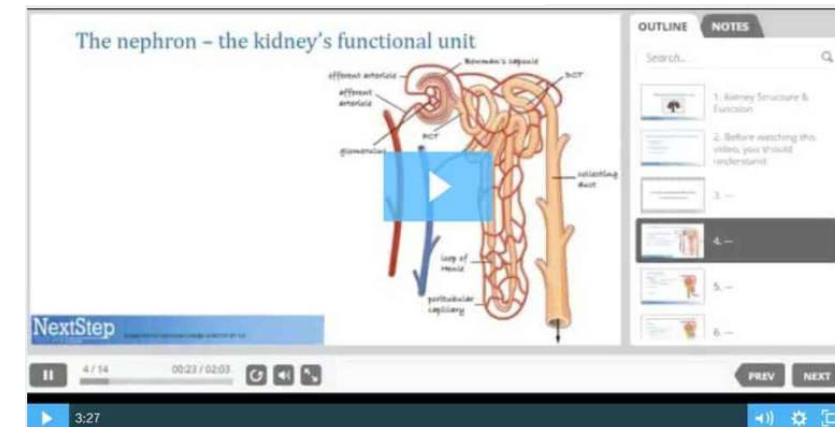
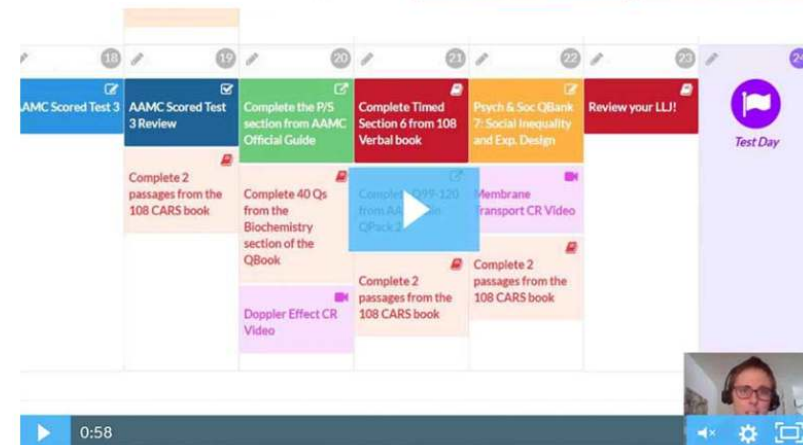
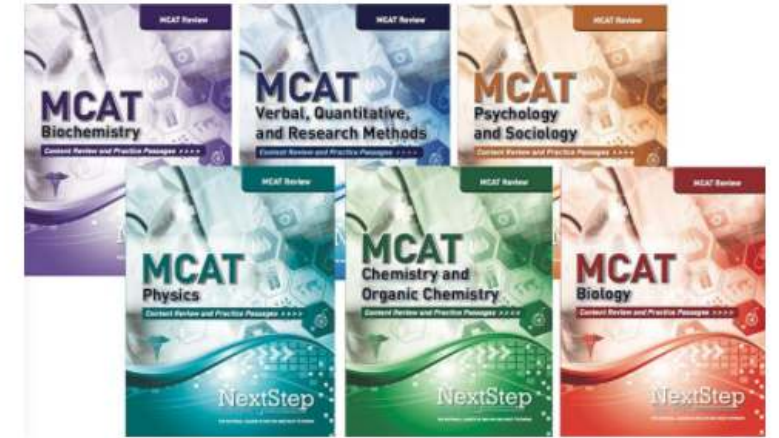
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