

SI Chemistry - Full Discipline Demo

Analysis of Phosphate in Water

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

⚡ Biogeochemical cycle	Ion composed of one phosphorus and 4 oxygen atoms	1
⚡ Eutrophication	Includes living organisms, rocks and minerals, and chemical reactions	2
⚡ Limiting nutrient	Availability determines population size	3
⚡ Phosphate	Caused by precipitation flowing over landscape and into waterways	4
⚡ Runoff pollution	Algal overgrowth resulting in hypoxia	5

Correct answers:

- 1 Phosphate 2 Biogeochemical cycle 3 Limiting nutrient
4 Runoff pollution 5 Eutrophication

Match each term with the best description.

⚡ Absorbance	The study of light energy and matter	1
⚡ Beer-Lambert law	Equal to the log ratio of initial light intensity and final light intensity	2
⚡ Calibration curve	$A = \epsilon bc$	3
⚡ Colorimeter	Measures light transmitted through a sample at a specific wavelength	4
⚡ Spectroscopy	Graph used to determine concentrations of unknown solutions	5

Correct answers:

- 1 Spectroscopy 2 Absorbance 3 Beer-Lambert law 4 Colorimeter
5 Calibration curve

Categorize each statement as true or false.

⚡ Absorbance decreases as solution concentration increases.	
⚡ Orthophosphates are stable and readily taken up by aquatic plants and phytoplankton.	
⚡ Phosphate is a non-essential nutrient for the algae that comprises the base of the aquatic food web.	
⚡ Phosphorus is highly reactive and rarely found as a pure, unbonded substance in nature.	
True	False
1	2

Correct answers:

1

Phosphorus is highly reactive and rarely found as a pure, unbonded substance in nature.

Orthophosphates are stable and readily taken up by aquatic plants and phytoplankton.

2

Absorbance decreases as solution concentration increases.

Phosphate is a non-essential nutrient for the algae that comprises the base of the aquatic food web.

Exploration

Phosphorus often occurs as a phosphate ion which is composed of ____ phosphorus atom(s) and ____ oxygen atom(s).

- ☐ 1; 2
- ☒ 1; 4 ✓
- ☐ 2; 3
- ☐ 3; 1

Phosphates are found in both the terrestrial and aquatic environments.

- ☒ True ✓
- ☐ False

Pollutant forms of phosphates include ____.

- ☐ fertilizers
- ☐ animal waste
- ☐ soap and cleaning products
- ☐ fertilizers and animal waste
- ☒ All of the above ✓

Orthophosphates are ____ compounds with ____ PO_4^{3-} group(s).

- ☐ organic; two
- ☒ inorganic; one ✓
- ☐ organic; three
- ☐ inorganic; two

An overgrowth of algae resulting in hypoxic aquatic environments is called ____.

- ☒ eutrophication ✓
- ☐ runoff pollution
- ☐ limiting nutrient
- ☐ biochemical pollution

As a solution becomes more concentrated, absorbance ____.

- ☒ increases ✓
- ☐ decreases
- ☐ remains the same

Multimeter resistance output is inversely proportional to the concentration of dye in a sample.

- ☐ True
- ☒ False ✓

Exercise 1

Describe the components of the colorimeter/multimeter and how it works.

A test tube containing solution is placed in the chamber of the colorimeter. The colorimeter contains a red LED light that will apply a peak wavelength of 650 nm to the solution. Within the colorimeter, electrical resistance in ohms (Ω) is detected by a cadmium sulfide photocell. A digital readout of the electrical resistance value is displayed on the multimeter.

Describe how electrical resistance readings from a colorimeter/multimeter can be used to explain the relationship between concentration and absorbance.

Electrical resistance is a measure of the movement of an electrical current through a material, which is a good indicator of light absorbance. As the concentration of phosphate in solution increases, the amount of light absorbed increases, and electrical resistance also increases. An approximate relationship between electrical resistance and absorbance is: $\text{Absorbance} = \log(\text{sample resistance}/\text{blank resistance})$.

Exercise 2

Describe the graphical relationship between resistance and concentration.

The graphical relationship between resistance and concentration is linear.

State the equation of your trendline.

Student answers will vary; the student's answer should match what is on their graph in **Graph 1**.

From what source did you collect your environmental water sample(s)?

Student answers will vary.

Did your calibration curve resemble the curve in Figure 6 of the background? How was it similar and how was it different?

The scale of the y-axis should be different. The slope of the line may differ, but both plots will have a linear trendline.

If this experiment was repeated without a colorimeter, could the presence and concentration of phosphates be determined? Explain your answer.

The presence of phosphates could be determined by the chemical addition. Solutions that have phosphates turn blue. The concentrations of phosphates in each sample could not be determined without a colorimeter. Two samples could be compared to see which one was a darker blue to determine which had a larger proportion of phosphates.

Phosphate concentrations greater than 1.0 ppm are associated with aquatic sources that have undergone eutrophication. Which of the samples that you analyzed are likely to have come from such an environment?

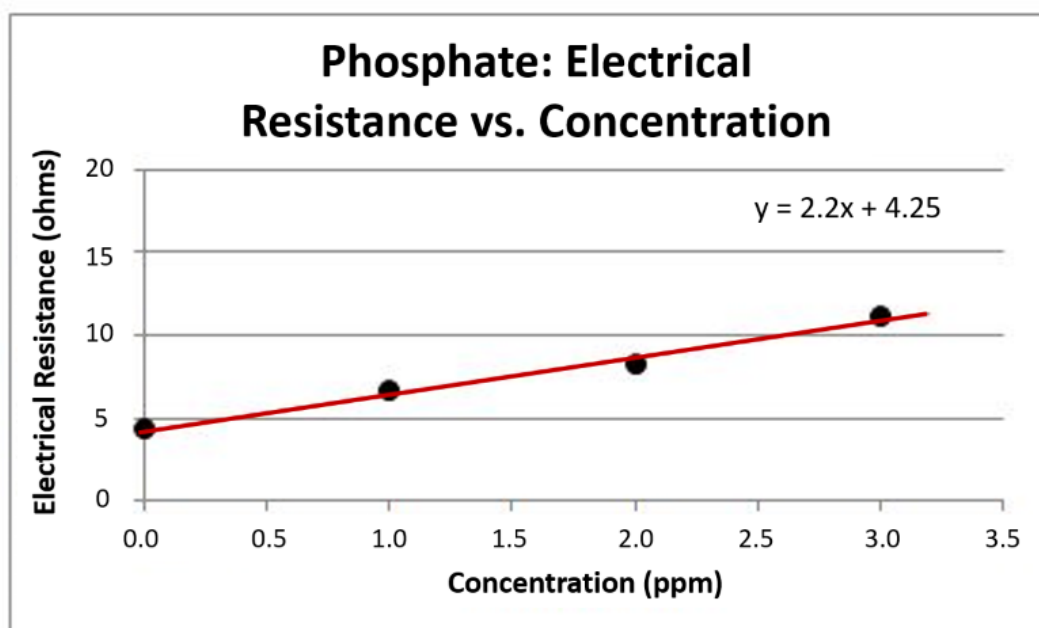
The Waste Water Treatment Plant did not likely have eutrophication, but the farm water ecosystem likely did have eutrophication.

Data Table 1: Electrical Resistance
(SAMPLE ANSWER BELOW)

Test Tube	Solution	Resistance (Ω)
0	0.0 ppm blank standard	3.8
1	1.0 ppm standard	6.2
2	2.0 ppm standard	8.6
3	3.0 ppm standard	11.5
w	Waste water treatment plant effluent	4.6
f	Stream outflow from a farm	6.5

e	Environmental sample	--
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Graph 1: Calibration Curve
(SAMPLE ANSWER BELOW)



Data Table 2: Phosphate Concentrations of Unknowns
(SAMPLE ANSWER BELOW)

Solution	Concentration (ppm)
Waste Water Treatment Plant Effluent	0.35
Stream Outflow from the Farm	1.10
Environmental Sample	--

Competency Review

Phosphate ions carry a ____ charge.

- ☐ +3
- ☐ -1
- ☒ -3
- ☐ +2

Phosphates are a(n) ____ nutrient for algae in freshwater ecosystems.

- ☒ essential
- ☐ non-limiting

An overgrowth of algae is beneficial to the environment because it produces an abundance of oxygen during photosynthesis.

- ☐ True
- ☒ False

____ phosphates are commonly found in rocks and soil.

- ☐ Organic
- ☒ Inorganic

Runoff pollution enters waterways during ____.

- ☐ rainfall
- ☐ snow
- ☐ direct dumping of pollutants
- ☐ rainfall, snow, and other precipitation events
- ☒ All of the above

✓

Spectroscopy is used to measure light ____ through chemical solutions.

- ☒ absorbance
- ☐ temperature
- ☐ repulsion
- ☐ intensity

✓

The Beer-Lambert law states the relationship between concentration and absorbance is ____.

- ☐ curvilinear
- ☒ linear
- ☐ circular
- ☐ nonlinear

✓

A colorimeter is a type of spectrophotometer which is used to measure the light transmitted through a sample by scanning continuously across multiple wavelengths.

- ☐ True
- ☒ False

✓

The colorimeter assembled for the experiment is powered by a ____ to function.

- ☐ multimeter
- ☒ battery
- ☐ alligator clip
- ☐ probe

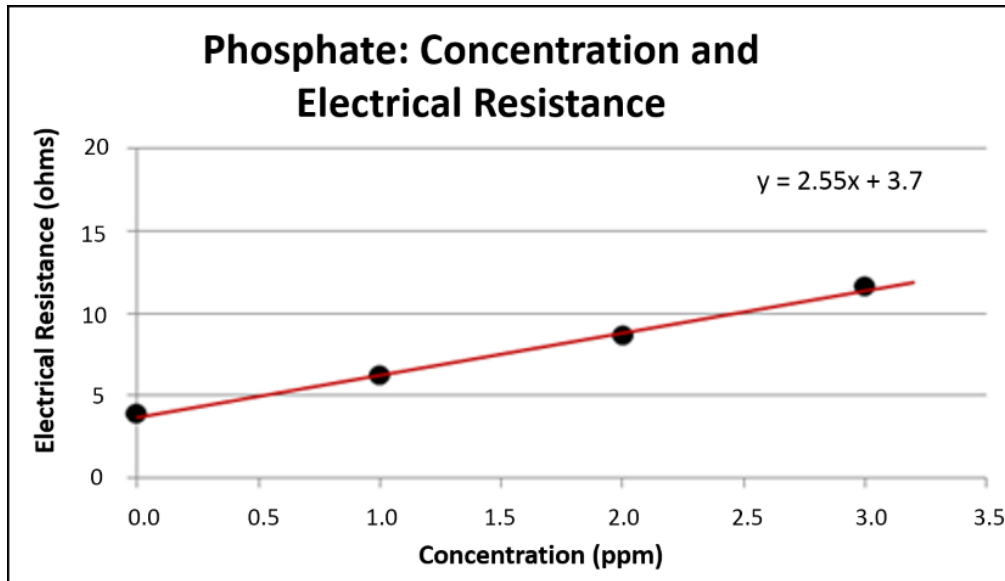
✓

Standard solutions are measured ____.

- ☐ to develop a calibration curve
- ☐ to reference when measuring unknowns
- ☒ All of the above
- ☐ None of the above

✓

An unknown colorimeter sample was measured at 10 ohms. Use the calibration curve to determine phosphate concentration of the sample.



- ☐ 1.5 ppm
- ☐ 2.0 ppm
- ☒ 2.5 ppm
- ☐ 3.0 ppm

✓

Extension Questions

Nitrate overabundance is also linked to eutrophication of aquatic ecosystems.

a. Research how spectrophotometry is used to determine nitrate levels and describe the compounds and colors produced by the associated reactions.

b. Why do nitrates serve as a better indicator of the possibility of a source of sewage or manure pollution than phosphates?

(SAMPLE ANSWER BELOW)

- a. The cadmium reduction method involves contact of the nitrate in the sample with cadmium particles, which causes nitrates to be converted to nitrites. The nitrites then react with another reagent to form a red color whose intensity is proportional to the original amount of nitrate.
- b. Nitrates from land sources end up in rivers and streams more quickly than other nutrients like phosphorus. This is because they dissolve in water more readily than phosphates, which have an attraction for soil particles. As a result, nitrates serve as a better indicator of the possibility of a source of sewage or manure pollution during dry weather.