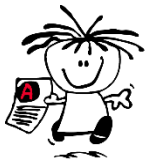
SCIENTIFIC INVESTIGATION GRADE 11 MEMO

Topics: Gaseous Exchange & Cellular Respiration
Term: 3
Total: 40



THE ANSWER SERIES *Your Key to Exam Success*

PREPARATION

Ensure learners have thorough understanding of:

- mitochondria and energy release during cellular respiration (Gr 10)
- measuring pulse rate and the effect of exercise (Gr 10)
- cellular respiration substrates and products (Gr 11)
- testing for the presence of CO_2 (Gr 11)
- acidification (carbonic acid) of water through the addition of CO_2 (Gr 11)
- movement of CO_2 through the body for exhalation (Gr 11)
- functioning and necessity of the respiratory centre (Gr 11)

Equipment and chemicals:

- phenolphthalein solution
- calcium hydroxide (lime)
- test tubes
- plastic straws or glass tubes

Slaked lime can be bought at your local pharmacy.

ALTERNATIVE
Lye (NaOH) can also be used instead of slaked lime. Drain cleaner pellets from the local supermarket are made of lye.

Purpose:

- The idea is to create a weak base-solution that will turn the phenolphthalein pink. As learners exhale CO_2 into the solution, carbonic acid (H_2CO_3) will form in the water. This slowly decreases the pH of the lime water solution until an acid-base neutral titration point is reached and the phenolphthalein turns colourless.
- Learners will measure the speed at which this happens which will indirectly indicate the volume of CO_2 (and carbonic acid) produced.
- With exercise, more cellular respiration (energy) is required and therefore heart rate increases to provide more glucose and oxygen to muscle cells.
- A corresponding increase in CO_2 production also happens.
- With exercise more CO_2 is exhaled, more carbonic acid will form in the water, changing the colour of the phenolphthalein solution faster.

Setup:

- Prepare a saturated lime water solution by adding between a ½ - 1 teaspoon slaked lime to 500 ml water. Stir until well dissolved. Add a few drops of phenolphthalein so that the solution turns pink.
- Test the concentration of the solution by pouring a small amount of it into a test tube and slowly exhaling/blowing into it through a straw.
- Since you will do this in a resting state, it should not take more than 5 minutes to change colour.
- If it takes longer, the concentration of the base-solution is too strong.

If you opt to use Lye, **very** little must be added to a lot of water to create a weak enough base solution (around 1 mℓ to 1 L). Testing the solution beforehand is very important in both instances.

- The educator must use their discretion here, since exercise will decrease the time it takes for the solution to change colour.

For more information on the solution: https://chem.libretexts.org/Ancillary_Materials/Demos_Techniques_and_Experiments/Lecture_Demonstrations/Magic_Breath

Explanation & reactions:

- Phenolphthalein is an acid/base indicator. It is colourless when it is an acid and pink when it is a base.
- Lime water is a calcium hydroxide solution ($Ca(OH)_2$) which is a base, so when the phenolphthalein was added to the solution, it turned the solution pink.
- When exhaling into the solution, the carbon dioxide in a person's breath reacted with the water to form carbonic acid (H_2CO_3).

$$CO_2 + H_2O \rightarrow H_2CO_3$$

- When enough carbonic acid is formed it neutralises the lime water, which is a base and makes the solution an acid. Therefore, with the phenolphthalein, the colour disappears in the now acidic solution.

$$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2H_2O$$

Time:

- The educator can choose to give learners 2 periods of class time to collect the data and complete the report, OR
- the learners can receive the instructions and Tables 1 to 3 of the investigation beforehand to allow time for them to collect the data after hours.
- Questions regarding their interpretation of the data must be done individually.

Aims addressed:

- SA 1
- SA 2: 1, 2, 3, 4, 5, 6, 7.2, 7.4, 7.5, 7.7, 7.8

MARKING GUIDELINE

1. Living organisms produce more carbon dioxide✓ during exercise✓.
   OR
   Exercise✓ increases the amount of carbon dioxide✓ released. (2)

2. Type OR intensity of activity/exercise✓ (1)

3. Amount of CO_2 released ✓ (1)

4. By measuring the time it takes for phenolphthalein solution to turn colourless✓ (1)

5. The heart rate increases✓ (1)

6. Muscles/cells require more energy✓/increased respiration during exercise
   blood flow increases to supply glucose✓/O_2 for this purpose (2)

7. More ✓ (1)

8. With exercise more CO_2✓ is released, therefore
the phenolphthalein solution took less time ✓
to turn colourless✓
when compared to the resting state ✓ *any (3)* (3)

9. Phenolphthalein turns colourless in an acid medium✓
When CO_2 dissolves in water✓
it creates an acid✓ (carbonic acid / H_2CO_3) (3)

10. *Educator to check results of investigation for exercise that increased heart rate the most and caused the fastest colour change in phenolphthalein solution.*
(specific type of exercise) ✓
The (specific type of exercise) was of a greater intensity✓/required more energy
therefore more CO_2✓released
more acid✓/carbonic acid/H_2CO_3 produced
faster drop in pH ✓ / colour change in the phenolphthalein solution (5)

11. Age group✓
Gender (if applicable) ✓
Type of exercise✓
Apparatus✓
Volume of liquid/ phenolphthalein solution in each test tube✓
Any other relevant contextual factor ✓ *first 2 only* (2)

12. Gender (if applicable) ✓
Fitness level✓
Age group (if applicable) ✓
Resting heart rate✓
Weight✓
Environment/time of day✓ (if learners did the experiment at different times)
Any other relevant contextual factor ✓

Not keeping these variables constant decreases✓ the validity of the investigation
first 2 only + 1 (3)

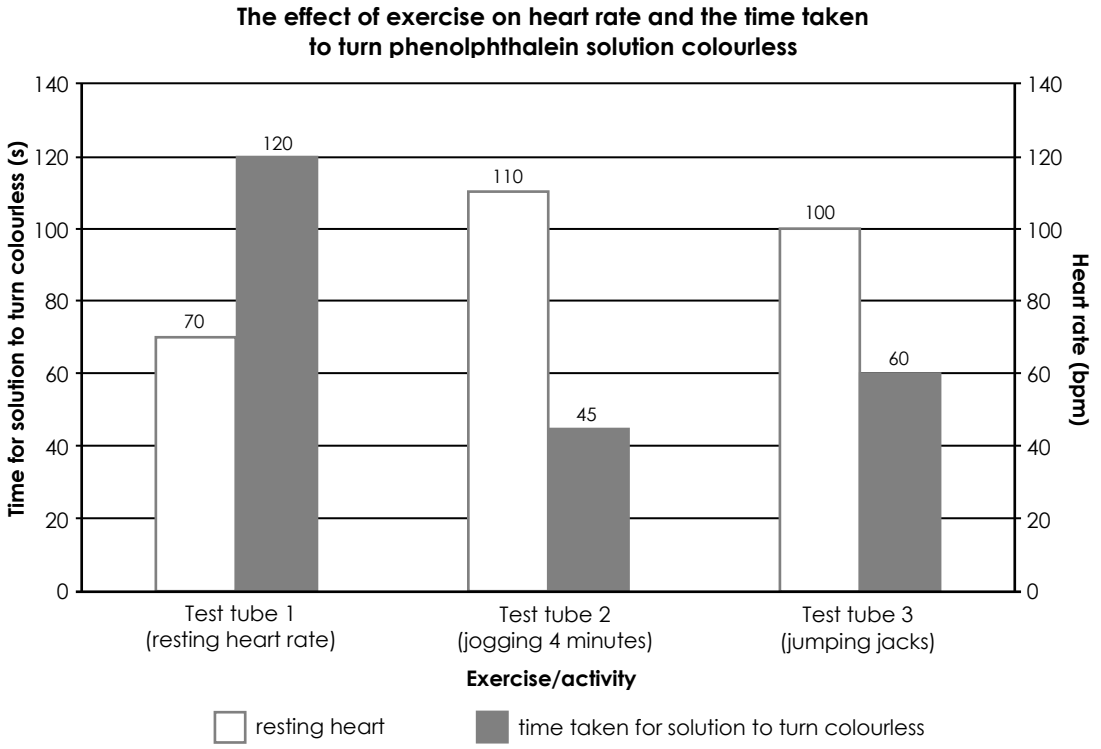
13. Large sample was used✓
to obtain a better average✓
OR
An average was calculated✓
for more representative/generalisable results✓ (2)

14. *Educator to check calculation of average for Activity 2 phenolphthalein time*

$$\text{Average} = \frac{\text{all values for Activity 2 of all groups counted together}}{\text{number of groups}}$$ ✓✓

= answer (nearest whole number) ✓ (3)

15.



✓Bar graph (**B**)
✓ Double graph (two graphs on one set of axes) (**D**)
✓✓✓Heading with all three variables (**H**)
✓Two y-axes drawn (**Y**)
✓X-axis categories correct
✓Y-axis intervals correct
✓✓ Plotting correct (**P**)

The data used in the graph is just an example and teachers should check learner graphs to their specific data.

(10)