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Danczak-Overton-Thompson Chemistry Critical Thinking Test

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Introduction

Critical thinking is a term used to describe a set of cognitive abilities to arrive at desirable outcomes such as predicting and solving problems, innovation, developing and critiquing arguments. Critical thinking is a highly desirable trait sought after by employers around the world from a variety of disciplines (especially the sciences).

This test is designed to inform higher education practitioners and researchers as to how they can better design science programs aimed at developing your critical thinking based on the results of your cohort. Completion of this test will not affect your academic record in any way.

In the proceeding sections you will be asked 30 multiple choice questions, suitable for any level of chemistry knowledge, designed to assess five key areas of critical thinking:

MAKING ASSUMPTIONS
DEVELOPING HYPOTHESES
TESTING HYPOTHESES
DRAWING CONCLUSIONS
ANALYSING ARGUMENTS

Each section has its own set of instructions, so please read them carefully.

On behalf of your unit/subject/module coordinators and teaching staff we'd like to thank you for your contribution and hope you find the test interesting and challenging.

Regards,

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MAKING ASSUMPTIONS

An assumption is something that's taken for granted. Scientists generally clarify their assumptions in academic discussions. However some assumptions are implied. Some assumptions arise when the general consensus of the scientific community is that there is no additional proof or evidence required in the statement being made. Assumptions can be stated or implied.

For example:

A chemical company failed to fulfil a promise made in 2014 to develop innovations to reduce pollution because atmospheric carbon dioxide (CO_2) measured at the start of 2015 was above 350ppm.

It is a **VALID ASSUMPTION** that atmospheric carbon dioxide (CO_2) is an indicator of pollution.

It is an **INVALID ASSUMPTION** that the chemical company made no attempt to fulfil this promise.

Instructions:

- In this section you are presented with short passages followed by several assumptions.
- Select **(A) Valid Assumption** if you think the assumption **can be taken for granted** based on the information presented in the short passage.
- Select **(B) Invalid Assumption** if you think the assumption ***cannot* be taken for granted** based on the information presented in the short passage.
- *Treat each question individually* and base your decisions relating only to the original passage.
- For this section ask yourself would a person who has not studied science at university consider the assumption to be valid or invalid.

The passage below is used for Questions 1, 2, 3 and 4.

Metals which are paramagnetic or diamagnetic behave differently when exposed to an induced magnetic field. A chemist tested a metallic alloy sample containing thallium and lead by placing it in an induced magnetic field. From the test results the chemist decided the metallic alloy sample repelled the induced magnetic field and therefore was diamagnetic.

1. The thallium within the metallic alloy sample is responsible for determining how a metallic alloy interacts with an induced magnetic field.

A) Valid Assumption B) Invalid Assumption

2. Paramagnetic metals do not repel induced magnetic fields.

A) Valid Assumption B) Invalid Assumption

3. Metals can only ever be paramagnetic or diamagnetic.

A) Valid Assumption B) Invalid Assumption

4. A diamagnetic metal alloy cannot be a paramagnetic metal alloy.

A) Valid Assumption B) Invalid Assumption

The passage below is used for Questions 5, 6 and 7.

Carbonate (CO_3^{2-}) has a formal charge of negative 2. Carbonate (CO_3^{2-}) can accept two hydrogen ions (H^+) which each have a formal charge of positive 1. Carbonate (CO_3^{2-}) is an example of a diprotic base. A monoprotic base such as hydroxide (OH^-) has a formal charge of negative 1. Hydroxide (OH^-) can only accept one hydrogen ion (H^+).

5. Carbonate (CO_3^{2-}) accepts hydrogen ions (H^+) more easily than monoprotic bases.

A) Valid Assumption B) Invalid Assumption

6. Hydrogen ions (H^+) have greater attraction towards bases with a more negative formal charge.

A) Valid Assumption B) Invalid Assumption

7. The greater the formal negative charge of a base, the more hydrogen ions (H^+) it can accept.

A) Valid Assumption B) Invalid Assumption

DEVELOPING HYPOTHESES

When generating hypotheses, scientists will draw inferences based on the data, observations and the supposed facts. An inference is used to fill in the gaps to create a connection, or look for the intended meaning. These inferences are not certain, but based on the information available, there is confidence in the hypothesis being developed.

For Example:

A chemist added one chemical to another and this was followed immediately by a colour change.

It is **LIKELY TO BE AN ACCURATE INFERENCE** that this occurred due to a reaction between the two chemicals. ***Based on the observations*** that the colour change occurred upon addition of the chemicals and the ***reasonable assumption*** that some reactions can result in a colour change this is **LIKELY TO BE AN ACCURATE INFERENCE**.

In the above example there would be **INSUFFICIENT INFORMATION TO DETERMINE THE ACCURACY** of a hypothesis which suggests one of the chemicals is more reactive than the other. ***More detailed observations are required***, for example reacting the chemicals in question with other chemicals.

If a chemist were to suggest that when two chemicals react they will always produce a colour change, this would be **LIKELY TO BE AN INACCURATE INFERENCE**. The ***conclusion is drawn from outside the information*** presented: they haven't tested other chemicals, and make an ***unreasonable assumption*** that all reactions result in a colour change.

Instructions:

- In this section you are presented with short passages followed by several inferences.
- You need to decide if each inference is/has:
  A) Likely to be an accurate inference
  B) Insufficient information to determine the accuracy
  C) Likely to be an inaccurate inference

- *Treat each question individually* and base your decisions relating only to the original passage.

The passage below is used for Questions 8, 9 and 10.

The following is an excerpt adapted from an article posted by NASA at the URL: www.nasa.gov/press-release/nasa-confirms-evidence-that-liquid-water-flows-on-today-s-mars

Using an imaging spectrometer researchers detected signatures of hydrated minerals on slopes where mysterious streaks are seen on the red planet. These darkish streaks appear to ebb and flow over time. They darken and appear to flow down steep slopes during warm seasons, and then fade in cooler seasons. They appear in several locations on Mars when temperatures are above minus 23 degrees Celsius (minus 10 degrees Fahrenheit), and disappear at colder times.

"Our quest on Mars has been to 'follow the water,' in our search for life in the universe, and now we have convincing science that validates what we've long suspected," said John Grunsfeld, astronaut and associate administrator of NASA's Science Mission Directorate in Washington. "This is a significant development, as it appears to confirm that water -- albeit briny -- is flowing today on the surface of Mars."

These downhill flows, known as recurring slope lineae (RSL), often have been described as possibly related to liquid water. The new finding may help to explain the dark features. The hydrated salts would lower the freezing point of a liquid brine, just as salt on roads here on Earth causes ice and snow to melt more rapidly. Scientists say it's likely a shallow subsurface flow, with enough water wicking to the surface to explain the darkening.

8. It is a fact that water can exist in a liquid state below zero degrees Celsius due to the presence of the hydrated salts. On Mars this could lead to the freezing and thawing of water resulting in the ebb and flow of the mysterious streaks on Mars.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

9. Some planets are likely to have similar conditions to Mars and NASA is planning to determine if there may be habitable water on these other planets.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

10. The imaging spectrometer directly detects water on Mars.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

The passage below is used for Questions 11, 12 and 13.

The following is an excerpt adapted from an article posted by CSIRO at the URL:
www.csiro.au/en/News/News-releases/2015/Marine-debris

Researchers from CSIRO and Imperial College London have assessed how widespread the threat of plastic is for the world's seabirds and found the majority of species have plastic in their gut.

The study, led by Dr Chris Wilcox with co-authors Dr Denise Hardesty and Dr Erik van Sebille and published today in the journal PNAS, found that nearly 60 percent of all seabird species have plastic in their gut. Based on analysis of published studies since the early 1960s, the researchers found that plastic is increasingly common in seabirds' stomachs.

In 1960, plastic was found in the stomach of less than 5 per cent of individual seabirds, rising to 80 per cent by 2010. The researchers predict that plastic ingestion will affect 99 per cent of the world's seabird species by 2050, based on current trends. The scientists estimate that 90 per cent of all seabirds alive today have eaten plastic of some kind.

This includes bags, bottle caps, and plastic fibres from synthetic clothes, which have washed out into the ocean from urban rivers, sewers and waste deposits. Birds mistake the brightly coloured items for food, or swallow them by accident, and this causes gut impaction, weight loss and sometimes even death.

11. This passage implies that as a result of 90 percent of all seabirds having eaten plastic of some kind, some species of sea bird will become extinct.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

12. The number of seabirds to have eaten plastic of some kind has a strong link to pollution caused by consumer and industrial waste.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

13. The increase in the number of coloured plastic items is responsible for a decline in the number of seabirds which haven't eaten plastic.

A) Likely to be an accurate inference
B) Insufficient information to determine the accuracy
C) Likely to be an inaccurate inference

TESTING HYPOTHESES

Scientists conduct experiments to test hypotheses. They begin with a hypothesis or statement they believe to be true and systematically seek information to confirm or refute the hypothesis. This results in a premise which is believed to be accurate or true.

For Example:

After completing a synthesis, a chemist compared the compound produced to a specific property of the starting material. The hypothesis is that if the specific property of the compound produced is different to that of the starting material there is no starting material in the compound produced. The chemist finds that the compound produced is very different with respect to this specific property of the starting material.

A **REASONABLE DEDUCTION** is that there is no starting material in the product. The ***evidence presented is supported by this hypothesis***.

An **UNREASONABLE DEDUCTION** would be that based on these observation the compound produced is certainly the chemical the chemist was intending to produce. ***The deduction is not related to the hypothesis*** and there is ***insufficient evidence to support this claim***.

Instructions:

- In this section you are presented with short passages followed by several hypotheses.
- You need to decide if each hypothesis is a **(A) reasonable deduction** or an **(B) unreasonable deduction**.
- Base your choice only on the information in the short passages.
- Assume that the information in the short passages are true.
- *Treat each question individually* and base your decisions relating only to the original passage.