PEQ 11.1 (Paper 1,2)

1. *[1 mark]*

Which are likely to be reduced when an experiment is repeated a number of times?

A. Random errors

B. Systematic errors

C. Both random and systematic errors

D. Neither random nor systematic errors

Markscheme

A

2. *[1 mark]*

A student recorded the volume of a gas as $0.01450\ \text{dm}^3$. How many significant figures are there in this value?

A. 3

B. 4

C. 5

D. 6

Markscheme

B

3. *[1 mark]*

Which would be the best method to decrease the **random** uncertainty of a measurement in an acid-base titration?

A. Repeat the titration

B. Ensure your eye is at the same height as the meniscus when reading from the burette

C. Use a different burette

D. Use a different indicator for the titration

Markscheme

A

4. *[1 mark]*

Density can be calculated by dividing mass by volume. $0.20 \pm 0.02\ \text{g}$ of a metal has a volume of $0.050 \pm 0.005\ \text{cm}^3$. How should its density be recorded using this data?

A. $4.0 \pm 0.025\ \text{g cm}^{-3}$

B. $4.0 \pm 0.8\ \text{g cm}^{-3}$

C. $4.00 \pm 0.025\ \text{g cm}^{-3}$

D. $4.00 \pm 0.8\ \text{g cm}^{-3}$

Markscheme

B

5. *[1 mark]*

How many significant figures are there in 0.00370?

A. 2

B. 3

C. 5

D. 6

Markscheme

B

6. *[1 mark]*

A student heated a solid in a crucible. The student measured the mass of the solid and crucible before and after heating and recorded the results.

$$\begin{aligned}\text{Mass of crucible and solid before heating} &= 101.692\ \text{g}\\ \text{Mass of crucible and solid after heating} &= 89.312\ \text{g}\end{aligned}$$

What value should the student record for the mass lost in grams?

A. 12.4

B. 12.38

C. 12.380

D. 12.3800

Markscheme

C

7. *[1 mark]*

A burette reading is recorded as $27.70 \pm 0.05\ \text{cm}^3$. Which of the following could be the actual value?

I. $27.68\ \text{cm}^3$

II. $27.78\ \text{cm}^3$

III. $27.74\ \text{cm}^3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

B

8. *[1 mark]*

A piece of metallic aluminium with a mass of 10.044 g was found to have a volume of $3.70\ \text{cm}^3$. A student carried out the following calculation to determine the density.

$$\text{Density}\ (\text{g}\,\text{cm}^{-3}) = \frac{10.044}{3.70}$$

What is the best value the student could report for the density of aluminium?

A. $2.715\ \text{g cm}^{-3}$

B. $2.7\ \text{g cm}^{-3}$

C. $2.71\ \text{g cm}^{-3}$

D. $2.7146\ \text{g cm}^{-3}$

Markscheme

C

9. *[1 mark]*

$50\ \text{cm}^3$ of copper(II) sulfate solution is measured into a plastic cup using a $100\ \text{cm}^3$ measuring cylinder. Excess zinc powder is added and the temperature rise that occurs is measured with a –10 °C to +110 °C thermometer. The enthalpy change for the reaction is then calculated. Which statement is correct?

A. Systematic error will be reduced by repeating the experiment several times and averaging the results.

B. Random error will be reduced by insulating the plastic cup.

C. Random error will be reduced by using a $50\ \text{cm}^3$ graduated pipette instead of a measuring cylinder.

D. Systematic error will be increased by using a larger volume of copper(II) sulfate solution.

Markscheme

C

10. *[1 mark]*

A student measured the mass and volume of a piece of silver and recorded the following values.

Mass of empty weighing bottle	1.0800 g
Mass of weighing bottle with piece of silver	11.5700 g
Volume of silver	$1.00\ \text{cm}^3$

Which value, in $\mathrm{g\,cm^{-3}}$, for the density of silver should the student report in her laboratory notebook?

A. 10.49

B. 10.4900

C. 10.5

D. 10.500

Markscheme

C

11. *[1 mark]*

Which would be the best method to decrease the random uncertainty of a measurement in an acid–base titration?

A. Ensure your eye is at the same height as the meniscus when reading the burette.

B. Use a different indicator for the titration.

C. Use a different burette.

D. Repeat the titration.

Markscheme

D

12a. *[2 marks]*

Reaction kinetics can be investigated using the iodine clock reaction. The equations for two reactions that occur are given below.

Reaction A: $\mathrm{H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)}$

Reaction B: $\mathrm{I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)}$

Reaction B is much faster than reaction A, so the iodine, $\mathrm{I_2}$, formed in reaction A immediately reacts with thiosulfate ions, $\mathrm{S_2O_3^{2-}}$, in reaction B, before it can react with starch to form the familiar blue-black, starch-iodine complex.

In one experiment the reaction mixture contained:

$5.0 \pm 0.1\ \text{cm}^3$ of $2.00\ \text{mol dm}^{-3}$ hydrogen peroxide (H_2O_2)

$5.0 \pm 0.1\ \text{cm}^3$ of 1% aqueous starch

$20.0 \pm 0.1\ \text{cm}^3$ of $1.00\ \text{mol dm}^{-3}$ sulfuric acid (H_2SO_4)

$20.0 \pm 0.1\ \text{cm}^3$ of $0.0100\ \text{mol dm}^{-3}$ sodium thiosulfate ($Na_2S_2O_3$)

$50.0 \pm 0.1\ \text{cm}^3$ of water with 0.0200 ± 0.0001 g of potassium iodide (KI) dissolved in it.

After 45 seconds this mixture suddenly changed from colourless to blue-black.

Apart from the precision uncertainties given, state **one** source of error that could affect this investigation and identify whether this is a random error or a systematic error.

Markscheme

Random: synchronizing mixing and starting timing / (reaction) time / uncertainty of concentrations of solutions / temperature of solutions/room temperature;

OR

Systematic: liquid remaining in measuring cylinders / not all solid KI transferred / precision uncertainty of stopwatch / ability of human eye to detect colour change / parallax error;

Accept concentration of stock solution and human reaction time as systematic error.

Award M1 for correctly identifying a source of error and M2 for classifying it.

Accept other valid sources of error.

*Do **not** accept "student making mistakes" / OWTTE.*

12b. *[1 mark]*

Calculate the total uncertainty, in cm^3, of the volume of the reaction mixture.

Markscheme

$(5 \times 0.1) = (\pm)0.5\ (\text{cm}^3)$;

13. *[2 marks]*

A student decided to determine the molecular mass of a solid monoprotic acid, HA, by titrating a solution of a known mass of the acid.

The following recordings were made.

Mass of bottle / g ± 0.001 g	1.737
Mass of bottle + acid HA / g ± 0.001 g	2.412

Calculate the mass of the acid and determine its absolute and percentage uncertainty.

Markscheme

0.675 (g) ± 0.002 (g);

Percentage uncertainty: 0.3%;

Accept answers correct to one, two or three significant figures for percentage uncertainty.

14a. *[1 mark]*

Iron tablets are often prescribed to patients. The iron in the tablets is commonly present as iron(II) sulfate, $\mathrm{FeSO_4}$.

Two students carried out an experiment to determine the percentage by mass of iron in a brand of tablets marketed in Cyprus.

Experimental Procedure:

- The students took five iron tablets and found that the **total mass** was 1.65 g.
- The five tablets were ground and dissolved in $100\ \mathrm{cm^3}$ dilute sulfuric acid, $\mathrm{H_2SO_4(aq)}$. The solution and washings were transferred to a $250\ \mathrm{cm^3}$ volumetric flask and made up to the mark with deionized (distilled) water.
- $25.0\ \mathrm{cm^3}$ of this $\mathrm{Fe^{2+}(aq)}$ solution was transferred using a pipette into a conical flask. Some dilute sulfuric acid was added.
- A titration was then carried out using a $5.00 \times 10^{-3}\ \mathrm{mol\,dm^{-3}}$ standard solution of potassium permanganate, $\mathrm{KMnO_4(aq)}$. The end-point of the titration was indicated by a slight pink colour.

The following results were recorded.

	Rough titre	First accurate titre	Second accurate titre
Initial burette reading / $cm^3 \pm 0.05$	1.05	1.20	0.00
Final burette reading / $cm^3 \pm 0.05$	20.05	18.00	16.80

When the $Fe^{2+}(aq)$ solution was made up in the $250\ cm^3$ volumetric flask, deionized (distilled) water was added until the bottom of its meniscus corresponded to the graduation mark on the flask. It was noticed that one of the two students measured the volume of the solution from the top of the meniscus instead of from the bottom. State the name of this type of error.

Markscheme

systematic (error);

Do not accept parallax.

14b. *[1 mark]*

State what is meant by the term *precision*.

Markscheme

closeness of agreement of a set of measurements to each other / *OWTTE*;

Allow reproducibility/consistency of measurement / measurements with small random errors/total amount of random errors/standard deviation / a more precise value contains more significant figures / OWTTE.

15. *[1 mark]*

In an experiment to determine a specific quantity, a student calculated that her experimental uncertainty was 0.9% and her experimental error was 3.5%. Which statement is correct?

A. Only random uncertainties are present in this experiment.

B. Both random uncertainties and systematic errors are present in this experiment.

C. Repeats of this experiment would reduce the systematic errors.

D. Repeats of this experiment would reduce both systematic errors and random uncertainties.

Markscheme

B

16. *[1 mark]*

A student carries out a titration three times and obtains the following volumes: $3.0 \pm 0.1\ \text{cm}^3$, $3.2 \pm 0.1\ \text{cm}^3$ and $3.2 \pm 0.1\ \text{cm}^3$. What is the average volume?

A. $3.1 \pm 0.1\ \text{cm}^3$

B. $3.13 \pm 0.1\ \text{cm}^3$

C. $3.1 \pm 0.3\ \text{cm}^3$

D. $3.13 \pm 0.3\ \text{cm}^3$

Markscheme

A

17. *[1 mark]*

Which statement about errors is correct?

A. A random error is always expressed as a percentage.

B. A systematic error can be reduced by taking more readings.

C. A systematic error is always expressed as a percentage.

D. A random error can be reduced by taking more readings.

Markscheme

D

18. *[1 mark]*

The heat change in a neutralization reaction can be determined by mixing equal volumes of HCl(aq) and NaOH(aq) of the same concentration in a glass beaker. The maximum temperature change is recorded using an alcohol thermometer.

What is the biggest source of error in this experiment?

A. Heat absorbed by the glass thermometer

B. Random error in the thermometer reading

C. Heat loss to the surroundings

D. Systematic error in measuring the volumes of HCl(aq) and NaOH(aq) using burettes

Markscheme

C

19. *[1 mark]*

A student weighs a standard 70.00 g mass five times using the same balance. Each time she obtains a reading of 71.20 g. Which statement is correct about the precision and accuracy of the measurements?

A. Precise and accurate

B. Precise but inaccurate

C. Accurate but not precise

D. Neither accurate nor precise

Markscheme

B

20. *[1 mark]*

What is the best way to minimize the random uncertainty when titrating an acid of unknown strength against a standard solution of sodium hydroxide (*ie* one of known concentration)?

A. First standardize the sodium hydroxide solution against a standard solution of a different acid.

B. Use a pH meter rather than an indicator to determine the equivalence point.

C. Keep your eye at the same height as the meniscus when reading the burette.

D. Repeat the titration several times.

Markscheme

D
