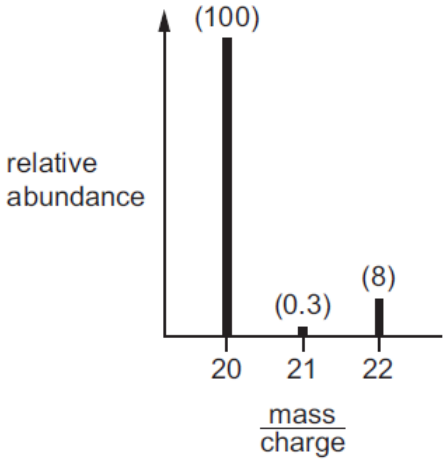
Atoms, molecules and stoichiometry – 2021 AS

1. Nov/2021/Paper_11/No.1

The mass spectrum of a sample of neon is shown. The relative abundance of each peak is written in brackets above it.



What is the relative atomic mass, A_r, of this sample of neon?

A 20.15 **B** 20.20 **C** 21.00 **D** 21.82

2. Nov/2021/Paper_11/No.2

2.0 g of ammonium nitrate, NH_4NO_3, decomposes to give 0.90 g of water and a single gas.

What is the identity of the gas?

A NO **B** NO_2 **C** N_2O **D** N_2

3. Nov/2021/Paper_11/No.3

Which of these elements has the highest fifth ionisation energy?

A C **B** N **C** P **D** Si

4. Nov/2021/Paper_11/No.4

The ion X^{2+} has the same electronic configuration as the atom Kr.

What is the electronic configuration of an atom of X?

A $[Ar]4s^23d^{10}4p^6$

B $[Ar]4s^23d^{10}4p^65s^2$

C $[Ar]4s^24d^{10}4p^6$

D $[Ar]4s^24d^{10}4p^65s^2$

5. Nov/2021/Paper_11/No.12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

C phosphorus

D sodium

6. Nov/2021/Paper_12/No.1

Compound X consists of 40.0% carbon, 6.7% hydrogen and 53.3% oxygen by mass.

What is the empirical formula of compound X?

A CH_2O **B** C_2H_2O **C** C_2H_4O **D** CHO

7. Nov/2021/Paper_12/No.2

Which statement is correct?

A 1.0 g of hydrogen gas contains 3.0×10^{23} atoms.

B 4.0 g of helium gas contains 1.2×10^{24} atoms.

C 16 g of methane gas contains 3.0×10^{24} atoms.

D 44 g of carbon dioxide gas contains 6.0×10^{23} atoms.

8. Nov/2021/Paper_12/No.3

Technetium (Tc) is a second row transition element that does not occur naturally on Earth. One of its isotopes has 56 neutrons.

What is the nucleon number of this isotope?

A 43 **B** 56 **C** 99 **D** 112

9. Nov/2021/Paper_12/No.4

Which atom has more unpaired electrons than paired electrons in orbitals of principal quantum number 2?

A carbon

B nitrogen

C oxygen

D fluorine

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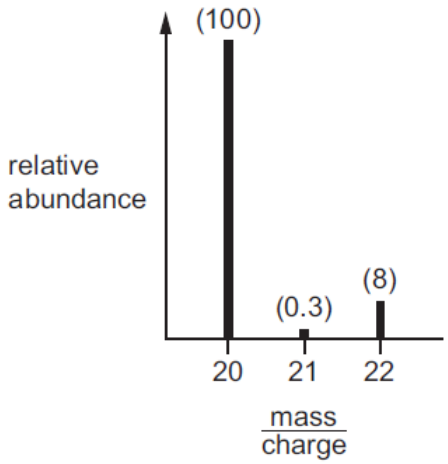

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D $[Ar]4s^24d^{10}4p^65s^2$

14. Nov/2021/Paper_13/No.7

In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid. The increase in temperature is 12 °C.

In a second experiment, the same method is used, but 50.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid.

What is the increase in temperature in the second experiment?

A 6 °C **B** 12 °C **C** 24 °C **D** 48 °C

15. Nov/2021/Paper_13/No.12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

C phosphorus

D sodium

16. Nov/2021/Paper_21/No.1(d)

(d) The compound As_2S_3 is a common mineral.

When As_2S_3 is heated strongly in air, it forms a mixture of products, as shown.

$$2As_2S_3(s) + 9O_2(g) \rightarrow As_4O_6(s) + 6SO_2(g)$$

(i) A sample containing 0.198 g As_2S_3 is placed in 0.100 dm^3 of pure oxygen, an excess, in a reaction chamber connected to a gas syringe at room temperature.

The reactants are heated until no further change is observed. The products are then allowed to cool to room temperature.

Calculate the volume, in dm^3, of gas present at the end of the experiment.

The molar volume of gas is 24.0 $dm^3 mol^{-1}$ under these conditions. Assume that the pressure is constant throughout the experiment.

Show your working.

volume of gas remaining = ... dm^3
[4]

(ii) State the environmental consequences of releasing $SO_2(g)$ into the atmosphere.

..... [1]

(iii) $SO_2(g)$ can be removed from the air by reacting it with NaOH(aq).

Construct an equation for the reaction of $SO_2(g)$ with NaOH(aq). Include state symbols.

..... [2]

17. March/2021/Paper_12/No/.1

The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

	number of protons	number of neutrons	number of electrons
W	32	40	32
X	32	40	34
Y	32	42	32
Z	34	40	34

Which pair represents the atoms of two isotopes of the same element?

A W and Y **B** W and Z **C** X and Y **D** X and Z

18. March/2021/Paper_12/No/.2

Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^2 4p^3$?

	Group	Period
A	13	3
B	13	4
C	15	3
D	15	4

19. March/2021/Paper_12/No/.3

Substance Q is a hydrocarbon. When 1.00 g of Q is completely burned, 3.22 g of carbon dioxide is produced.

What could be the identity of Q?

A cyclohexene

B cyclopentane

C ethene

D pentane

20. March/2021/Paper_12/No/.4

Originally, chemists thought indium oxide had the formula InO. By experiment they showed that 4.8 g of indium combined with 1.0 g of oxygen to produce 5.8 g of indium oxide. The A_r of oxygen was known to be 16.

Which value for the A_r of indium is calculated using these data?

A 38 **B** 77 **C** 115 **D** 154

21. March/2021/Paper_12/No/.6

A solution contains 0.25 g of sulfur dioxide in 1.00 dm^3 of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of 1×10^5 Pa, must be added to 1.00 dm^3 of water to produce this solution?

A 0.0162 cm^3 **B** 0.105 cm^3 **C** 16.2 cm^3 **D** 105 cm^3

22. March/2021/Paper_12/No/.13

Which row is correct?

	statement	reason
A	The first ionisation energy of phosphorus is greater than that of magnesium.	electron is lost from a 3p orbital in both cases
B	The melting point of phosphorus is greater than that of magnesium.	phosphorus has more valence electrons than magnesium
C	The atomic radius of phosphorus is smaller than that of magnesium.	phosphorus has greater nuclear charge than magnesium
D	The electrical conductivity of phosphorus is smaller than that of magnesium.	bonding changes from ionic in magnesium to covalent in phosphorus

23. March/2021/Paper_12/No/.35

A sample containing x mol of Al_2Cl_6 is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, y mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

1 the initial pH of solution W is below 7

2 $y = 3x$

3 Z contains x mol of aluminium

24. June/2021/Paper_11/No.1

Which contains the largest number of hydrogen atoms?

A 0.10 mol of pentane

B 0.20 mol of but-2-ene

C 1.00 mol of hydrogen molecules

D 6.02×10^{23} hydrogen atoms

25. June/2021/Paper_11/No.2

In which pair of species do both species have only one unpaired p electron?

A Ar^+ and C^- **B** B and Ti^+ **C** F and Ga **D** Se^- and Si^-

26. June/2021/Paper_11/No.6

What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm^3 of propane measured under room conditions?

A 60 g **B** 80 g **C** 120 g **D** 160 g

27. June/2021/Paper_11/No.7

Why is the first ionisation energy of oxygen less than that of nitrogen?

A The nitrogen atom has its outer electron in a different subshell.

B The nuclear charge on the oxygen atom is greater than that on the nitrogen atom.

C The oxygen atom has a pair of electrons in one p orbital that repel one another.

D There is more shielding in an oxygen atom.

28. June/2021/Paper_12/No.1

Which statement about the Avogadro constant is correct?

A It is the mass of one mole of any element.

B It is the mass of 6.02×10^{23} atoms of any element.

C It is the number of atoms in one mole of neon.

D It is the number of atoms in 12 g of any element.

29. June/2021/Paper_12/No.2

Which equation represents the first ionisation energy of iodine?

A $\frac{1}{2}I_2(g) + e^- \rightarrow I^-(g)$

B $I(g) + e^- \rightarrow I^-(g)$

C $\frac{1}{2}I_2(g) \rightarrow I^+(g) + e^-$

D $I(g) \rightarrow I^+(g) + e^-$

30. June/2021/Paper_12/No.31

In which ions are the number of electrons equal to the number of neutrons?

1 $^{19}_{9}F^{-}$

2 $^{31}_{15}P^{-}$

3 $^{23}_{11}Na^{+}$

31. June/2021/Paper_13/No.1

Compound X is an organic compound that contains 30.6% carbon, 3.8% hydrogen, 20.4% oxygen and 45.2% chlorine by mass.

What is the empirical formula of X?

A C_2H_3OCl **B** C_2H_4OCl **C** C_3H_4OCl **D** $C_4H_3O_2Cl_2$

32. June/2021/Paper_13/No.2

A sample of propane, C_3H_8, with a mass of 9.61 g is completely combusted in an excess of oxygen under room conditions.

Which volume of carbon dioxide gas is produced?

A 4.89 dm^3 **B** 5.24 dm^3 **C** 14.7 dm^3 **D** 15.7 dm^3

33. June/2021/Paper_13/No.3

Which atom has the same number of electrons as an ammonium ion?

A Mg **B** Na **C** Ne **D** O

34. June/2021/Paper_13/No.9

Copper dissolves in dilute nitric acid producing a blue solution of $Cu(NO_3)_2$, water and nitrogen(II) oxide as the only products.

How many moles of acid react with three moles of copper in the balanced equation?

A 2 **B** 4 **C** 6 **D** 8

35. June/2021/Paper_13/No.31

Which statements about first ionisation energies are correct?

1 They are always endothermic.

2 They decrease down Group 2.

3 They decrease across Period 3.

36. June/2021/Paper_13/No.34

Element X is a solid under room conditions. It occurs as a contaminant of fossil fuels.

Its oxide, Y, is formed when fossil fuels are burned.

In the atmosphere, Y can be further oxidised to Z.

Which statements about X, Y and Z are correct?

1 Atoms of X have paired p electrons.

2 The atmospheric oxidation of Y to Z is a catalysed reaction.

3 With water, Z forms a strong acid.

37. June/2021/Paper_21/No.1

Ethanedioic acid, HO_2CCO_2H, has a relative molecular mass of 90.0.

(a) (i) Explain what is meant by the term *relative molecular mass*.

.....

.....

..... [2]

(ii) State the empirical formula of ethanedioic acid.

..... [1]

(iii) Calculate how many atoms of carbon are present in 0.18 g of ethanedioic acid, HO_2CCO_2H.

Show your working.

atoms of carbon present = ... [3]

(b) Solid ethanedioic acid reacts with aqueous calcium ions to make a precipitate of calcium ethanedioate, CaC_2O_4.

CaC_2O_4 breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

(i) Construct an equation to represent the reaction of CaC_2O_4 when heated. Include state symbols.

..... [2]

(ii) Identify the type of reaction which occurs when CaC_2O_4 is heated.

..... [1]

(iii) Identify another compound containing calcium ions which will also produce carbon dioxide and calcium oxide when it is heated.

..... [1]

[Total: 10]

38. June/2021/Paper_23/No.1(e)

(e) The concentration of NaC*l*O in bleach **S** is $x\,g\,dm^{-3}$.

NaC*l*O reacts with $H_2O_2(aq)$ as shown.

$$H_2O_2(aq) + NaClO(aq) \rightarrow H_2O(l) + NaCl(aq) + O_2(g)$$

A $5.00\,cm^3$ sample of **S** completely reacts with $H_2O_2(aq)$. The volume of $O_2(g)$ produced is $24.0\,cm^3$ under room conditions.

Assume that only the NaC*l*O in **S** reacts with $H_2O_2(aq)$.

Calculate *x*. Show your working.

x = ... $g\,dm^{-3}$

[3]