Anglo-Chinese School
(Independent)

Year 6 PRELIMINARY EXAMINATION 2023
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME
CHEMISTRY HIGHER LEVEL

PAPER 1

Monday 12th September 2022 1 hour

Additional materials:
Multiple choice answer sheet
Soft clean eraser
Soft pencil (type 2B recommended)

INSTRUCTIONS TO CANDIDATES
Do not open this booklet until you are told to do so.
Shade your Candidate number on the multiple choice answer sheet provided.

There are **forty** questions in this paper. Answer **all** the questions. For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the multiple choice answer sheet.

INFORMATION FOR CANDIDATES
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet. A copy of the periodic table is provided for reference on Page 2 of the examination paper.
Calculators are **not** allowed to be used in this paper.

This question paper consists of 18 printed pages, including the cover page.

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. In which of the following species would nitrogen be reduced if converted to N_2O_4?

A. NH_3

B. NO

C. NO_3^-

D. NO_2^-

2. How many electrons are needed when the following half-equation is balanced using the lowest possible whole numbers?

$$\_\_SO_2 + \_\_H_2O \longrightarrow \_\_SO_4^{2-} + \_\_\_H^+ + \_\_\_e^-$$

A. 1

B. 2

C. 3

D. 4

3. Typically, when a person coughs, he first inhales about 2.0 dm^3 of air at 1.0 atm and 25 °C. In the lungs, the air is warmed to 37 °C and compressed to a volume of about 1.7 dm^3 by the action of the diaphragm and chest muscles. The sudden opening of the vocal cord then releases the air explosively.

Just prior to this release, what is the approximate pressure (in atm) of the gas inside the lungs?

A. $\dfrac{1.0\times2.0\times37}{25\times1.7}$

B. $\dfrac{1.0\times2.0\times310}{298\times1.7}$

C. $\dfrac{25\times1.7}{1.0\times2.0\times37}$

D. $\dfrac{298\times1.7}{1.0\times2.0\times310}$

4. Which of the following statements contains one mole of the stated particle?
[At SATP, one mol of gas occupies 24.0 dm^3]

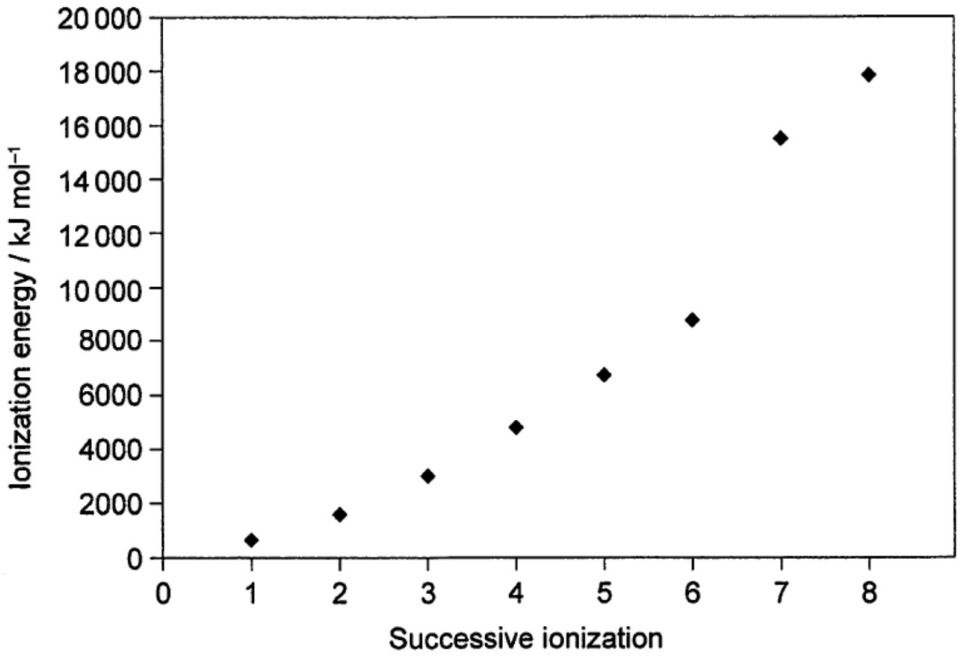
A. Molecules in 19.00 g of fluorine gas.

B. Electrons in 24.0 dm^3 of hydrogen gas at SATP.

C. Neutrons in 1.00 g of helium gas.

D. Protons in 2.018 g of neon gas.

5. The first eight successive ionization energies for an atom are shown. In which group is the atom found?



A. 15

B. 16

C. 17

D. 18

6. How many electrons are there in **all** the d orbitals in a xenon atom?

A. 10

B. 18

C. 20

D. 36

7. Which trend is correct across the period?

A. Atomic radius decreases

B. Electronegativity decreases

C. Ionic radius increases

D. Melting point decreases

8. Which of the following affects the colour of the complex formed by a particular transition metal?

I. Oxidation state of metal

II. Type of ligand

III. Geometry of the complex

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. Which of the following statements best explains why $[Fe(H_2O)F_5]^{2-}$ appears colourless?

A. The d orbitals are half-filled

B. The electrons do not undergo d-d transition.

C. The complex is octahedral in shape.

D. The energy gap between the d orbitals does not corresponds to radiation from the visible light region.

10. Which of the following correctly show the strongest intermolecular forces of attraction for the compound?

	Compound	**Strongest Intermolecular forces of attraction**
A.	CH_3CH_2F	Hydrogen bonding
B.	CH_2O	Dipole forces
C.	CH_2Cl_2	London dispersion force
D.	$C_6H_5CONH_2$	Dipole forces

11. Which species does not have resonance structures?

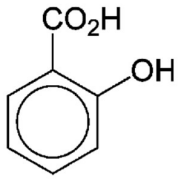
A. O_3

B. NO_3^-

C. CH_3COCH_3

D. CO_3^{2-}

12. The structure shows the bonding in salicylic acid.



Which statements are correct?

I The molecules do not form London dispersion forces between them.

II The carbon atom is the carboxyl group is sp^2 hybridised.

III The molecule can form intramolecular hydrogen bonding.

A. I and II only

B. I and III only

C. II and III only

D. All of the above

13. Which of the following compound contains the strongest ionic bond?

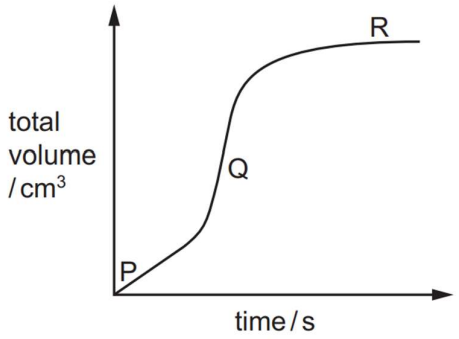
A. NaBr

B. NaCl

C. MgF_2

D. $MgCl_2$

14. A large excess of magnesium ribbon is added to dilute hydrochloric acid and the volume of hydrogen gas produced is measured as the reaction proceeds. The reaction is exothermic. The results are shown.



Which explains the changes in the rate of reaction between points P and Q and between points Q and R?

	between points P and Q	between points Q and R
A.	the reaction temperature increases	the acid concentration decreases
B.	magnesium's surface area decreases	the acid concentration decreases
C.	the reaction temperature increases	the magnesium has been used up
D.	magnesium's surface area decreases	the magnesium has been used up

15. When the temperature of a particular reaction is increased by 10 °C (e.g. from 20 °C to 30 °C) the rate of the reaction approximately doubles. What is the most significant reason for this increase?

A. A reduced activation energy for the reaction.

B. More particles colliding at the energy greater than the activation energy.

C. An increased collision frequency of the reactant molecules.

D. A different mechanism for the reaction.

16. A student mixes 2.50 g of excess zinc powder with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature increases by 3.5 °C. What is the enthalpy change for the reaction, in kJ mol^{-1}?
(specific heat capacity of water = 4.18 J g^{-1} K^{-1})

A. $\dfrac{27.5 \times 4.18 \times (3.5 + 273) \times 65.38}{2.50 \times 1000}$

B. $\dfrac{25.0 \times 4.18 \times 3.5}{25.0 \times 0.35}$

C. $\dfrac{25.0 \times 4.18 \times 3.5 \times 65.38}{2.50 \times 1000}$

D. $\dfrac{27.5 \times 4.18 \times (3.5 + 273)}{25.0 \times 0.35}$

17. Which equation represents the average bond energy of the C–H bond in methane?

A. ¼ CH_4 (g) → ¼ C (g) + H (g)

B. ¼ C (s) + H (g) → ¼ CH_4 (g)

C. CH_4 (g) → C (g) + 4H (g)

D. CH_4 (g) → CH_3 (g) + H (g)

18. The equation on an enthalpy change is shown.

$$2C\ (s) + 3H_2\ (g) + \frac{7}{2}\ O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$$

Given the following equations,

$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$ $\quad \Delta H^{\ominus} = x$ kJ

$H_2\ (g) + ½\ O_2\ (g) \rightarrow H_2O\ (l)$ $\quad \Delta H^{\ominus} = y$ kJ

What is correct expression for the enthalpy change of the reaction above?

A. $x + y + \Delta H_c^{\ominus}(O_2)$

B. $2x + 3y + \frac{7}{2}\Delta H_c^{\ominus}(O_2)$

C. $2y - 3x$

D. $3y + 2x$

19. Which is correct for a reaction with a negative change in Gibbs free energy, $\Delta G^{\ominus}$?

A. The reaction has a negative $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ at 298 K.

B. The reaction becomes spontaneous at higher temperature.

C. The reaction has maximum entropy.

D. The formation of product is favoured.

20. In which reaction does entropy increase?

A. $NaCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\ (s) + NaNO_3\ (aq)$

B. $H_2\ (g) + I_2\ (g) \rightarrow 2HI\ (g)$

C. $CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$

D. $H_2O\ (l) \rightarrow H_2O\ (s)$

21. Propanone reacts with iodine in the presence of an acid.

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_3COCH_2I + HI$$

The mechanism involves the following steps:

$$CH_3COCH_3 \xrightarrow{H^+} CH_3C(OH)=CH_2 \quad \text{(slow)}$$

$$CH_3C(OH)=CH_2 + I_2 \rightarrow CH_3CI(OH)CH_2I \quad \text{(fast)}$$

$$CH_3CI(OH)CH_2I \rightarrow CH_3COCH_2I + HI \quad \text{(fast)}$$

Which conclusion **cannot** be drawn from this information?

A. Iodine is not involved in the rate-determining step.

B. The acid acts as a catalyst.

C. The overall order of the reaction is 3.

D. The rate of reaction is not affected by a change in the iodine concentration.

22. Ethyne can form benzene when heated.

$$3HC{\equiv}CH\ (g) \rightarrow C_6H_6\ (l)$$

This reaction is found to be exothermic. Which conclusion can you draw from this information?

A. This reaction is spontaneous at all temperatures.

B. This reaction is not spontaneous at all temperatures.

C. This reaction is spontaneous at high temperatures.

D. This reaction is spontaneous at low temperatures.

23. The reaction 2X (g) + Y (g)→ 3Z (g) has the rate expression

$$\text{rate} = k\,[X]^2\,[Y]^0$$

The concentration of X is increased by a factor of three and the concentration of Y is increased by a factor of two. By what factor will the reaction rate increase?

A. 6

B. 9

C. 12

D. 18

24. The Haber Process combines nitrogen from the air with hydrogen derived mainly from natural gas (methane) into ammonia.

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g) \qquad K_c = y$$

Determine the K_c of the following equilibrium: $\frac{1}{2}\ NH_3\ (g) \rightleftharpoons \frac{1}{4}\ N_2\ (g) + \frac{3}{4}\ H_2\ (g)$

A. $(y)^{0.25}$

B. $\frac{4}{y}$

C. $\left(\frac{1}{y}\right)^{0.25}$

D. $\left(\frac{1}{y}\right)^{0.5}$

25. An aqueous solution of dichromate ions ($Cr_2O_7^{2-}$) is orange, whilst an aqueous solution of chromate ions (CrO_4^{2-}) is yellow. These two ions can be converted by the following reversible reaction.

$$2CrO_4^{2-}\ (aq) + 2H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$$

Which of the following chemicals when added will change a yellow solution of CrO_4^{2-} into orange $Cr_2O_7^{2-}$?

A. Add water

B. Add aqueous $Ba(OH)_2$

C. Add aqueous HNO_3

D. Add aqueous NH_3

26. Which of the following equilibrium composition is **not** affected when the total pressure is increased at a constant temperature?

A. $N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$

B. $2NO_2\ (g) \rightleftharpoons N_2O_4\ (g)$

C. $H_2\ (g) + I_2\ (g) \rightleftharpoons 2HI\ (g)$

D. $CaCO_3\ (s) \rightleftharpoons CaO\ (s) + CO_2\ (g)$

27. 10.0 cm^3 of an aqueous solution of hydrochloric acid of pH = 3 is mixed with 990.0 cm^3 of distilled water. What is the pH of the resulting solution?

A. 1

B. 2

C. 4

D. 5

28. What is the order of increasing pH for the following solutions of the same concentration?

A. $HCl\ (aq) < H_2SO_4\ (aq) < KNO_3\ (aq) < CH_3COONa$

B. $KNO_3\ (aq) < CH_3COONa < H_2SO_4\ (aq) < HCl\ (aq)$

C. $H_2SO_4\ (aq) < HCl\ (aq) < KNO_3\ (aq) < CH_3COONa$

D. $H_2SO_4\ (aq) < HCl\ (aq) < CH_3COONa < KNO_3\ (aq)$

29. Methyl orange is a weak acid and has a pK_a of 3.7. The dissociation of methyl orange (HIn) can be represented by the following equation.

$$\underset{\text{Red}}{HIn\ (aq)} \rightleftharpoons H^+\ (aq) + \underset{\text{yellow}}{In^-\ (aq)}$$

Which statement is correct?

A. Methyl orange can be used as an indicator for the titration between sodium hydroxide and ethanoic acid.

B. At pH = 7, red will be observed.

C. At pH = 4, orange will be observed.

D. At pH = 1, the major species will be $In^-\ (aq)$.

30. Which has the strongest conjugate acid?

A. NH_3 (pK_b = 4.75)

B. CH_3NH_2 (pK_b = 3.34)

C. $C_6H_5NH_2$ (pK_b = 9.13)

D. $(CH_3)_3N$ (pK_b = 4.20)

31. What is the $E^{\ominus}$ value, in V, for the reaction Zn (s) + Ni^{2+} (aq) → Zn^{2+} (aq) + Ni (s) deduced from the following equations?

$$Zn\ (s) + 2Ag^{+}\ (aq) \rightarrow Zn^{2+}\ (aq) + 2Ag\ (s) \quad E^{\ominus} = 1.56\ V$$

$$Ni\ (s) + Cu^{2+}\ (aq) \rightarrow Ni^{2+}\ (aq) + Cu\ (s) \quad E^{\ominus} = 0.60\ V$$

$$Cu\ (s) + 2Ag^{+}\ (aq) \rightarrow Cu^{2+}\ (aq) + 2Ag\ (s) \quad E^{\ominus} = 0.46\ V$$

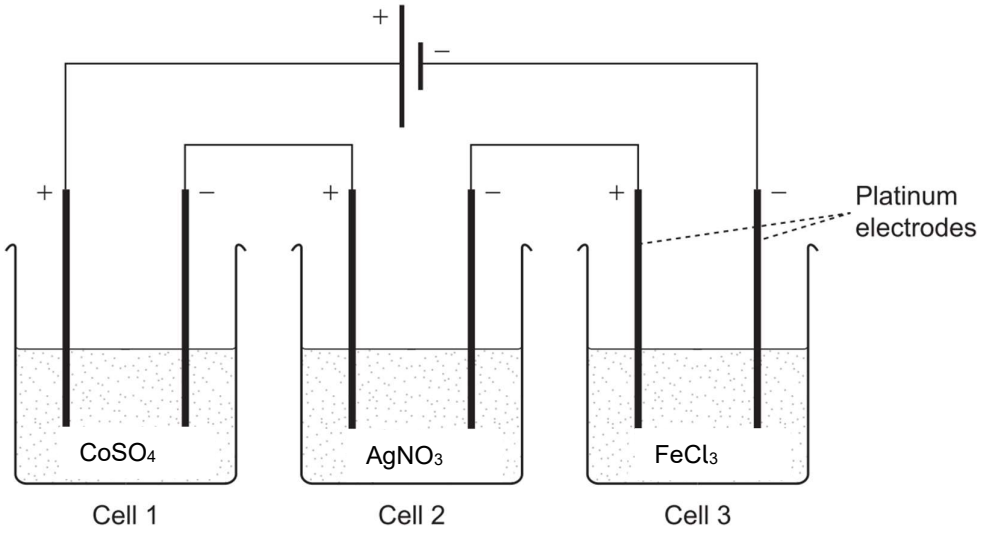
A. 0.50

B. 0.96

C. 1.10

D. 2.16

32. What is the order of increasing mass deposited by this electrolytic cell when the molten salts are electrolysed?



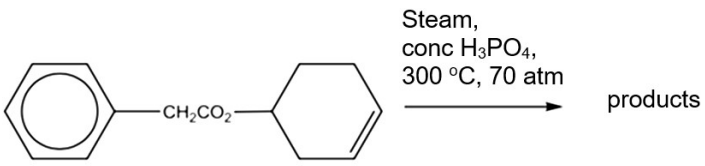
A. Ag < Co < Fe

B. Fe < Co < Ag

C. Co < Ag < Fe

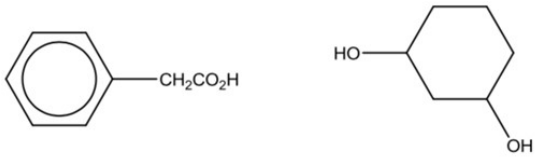
D. Co < Fe < Ag

33. The following shows a reaction:

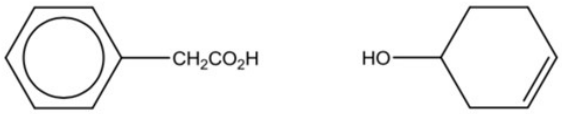


What could be the final products?

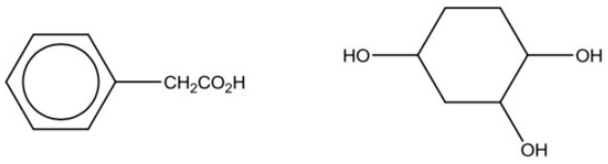
A.



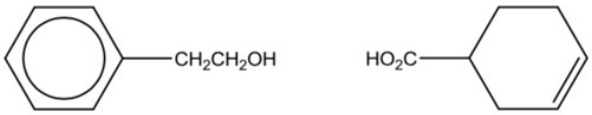
B.



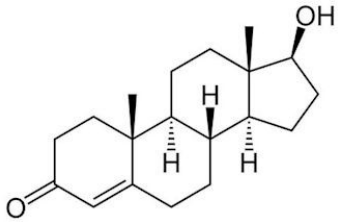
C.



D.



34. Testosterone is the primary sex hormone and anabolic steroid in males. How many enantiomers can Testosterone produce?



Testosterone

A. 2^5

B. 2^6

C. 2^7

D. 2^8

35. Which pair of reaction types is illustrated by the reaction sequence below?

$$CH_3CH{=}CHCH_3 \xrightarrow{HI \text{ in } CH_3CO_2H} CH_3CH_2CHICH_3 \xrightarrow{NaOH(aq)} CH_3CH_2CH(OH)CH_3$$

A. electrophilic addition and electrophilic substitution

B. electrophilic addition and nucleophilic substitution

C. nucleophilic addition and electrophilic substitution

D. nucleophilic addition and nucleophilic substitution

36. Ethene reacts with bromine to form dibromoethane. Which of the following best describes the intermediate in this reaction?

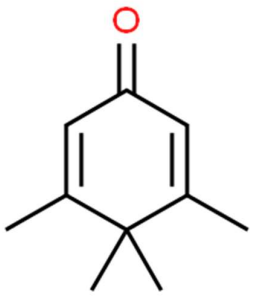
A. It can act as a nucleophile.

B. It is electron deficient.

C. Each carbon in the intermediate is sp^2 hybridised.

D. It contains delocalised electrons.

37. What is the IHD, index of hydrogen deficiency, of penguinone?



A. 2

B. 3

C. 4

D. 5

38. What is the ratio of the areas of the signals in the ^{1}H NMR spectrum of pentan-3-ol?

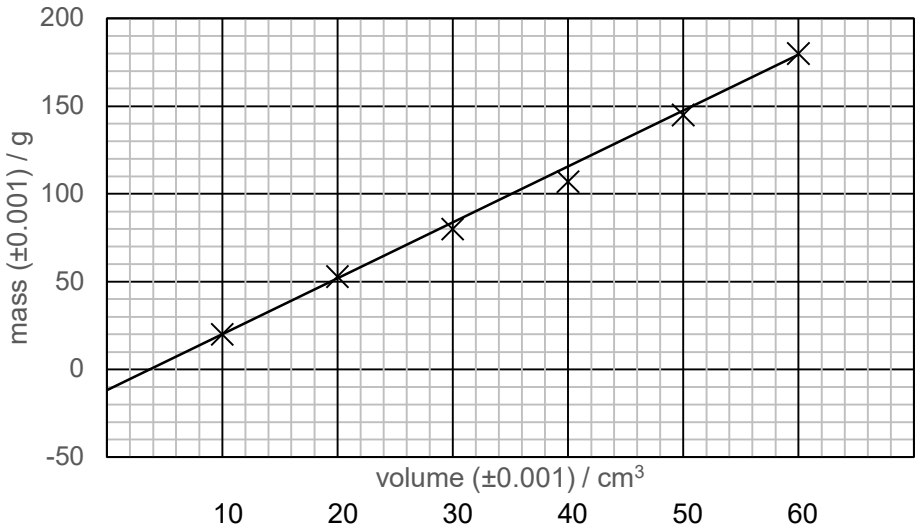
A. 6:4:1:1

B. 3:1:1:1

C. 5:5:1:1

D. 3:3:2:2:1:1

39. The volume and mass of different pieces of aluminium metal are measured independently. A graph of mass against volume is plotted as shown.



Which can be deduced from the results?

	density	significant error
A.	3.000	random
B.	3.000	systematic
C.	3.200	random
D.	3.200	systematic

40. A student prepared a standard solution of aqueous sodium carbonate, by dissolving (0.200 ± 0.002) g of anhydrous Na_2CO_3 solid in 10 cm^3 of deionised water in a (50 ± 5) cm^3 beaker. The resulting solution is transferred into a (100.0 ± 0.10) cm^3 volumetric flask and top up with deionised water to the 100 cm^3 mark.

What is the percentage uncertainty of the prepared concentration?

A. 1.1 %

B. 2.0 %

C. 6.0 %

D. 11.1 %