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香港考試及評核局
HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

2022年香港中學文憑
HONG KONG DIPLOMA OF SECONDARY EDUCATION 2022

CHEMISTRY PAPER 1
SECTION B

MARKING SCHEME

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3. The following symbols are used:

/	A single slash indicates an acceptable alternative within an answer.
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4. In questions asking for a specified number of reasons or examples etc. and a candidate gives more than the required number, the extra answers should not be marked. For instance, in a question asking candidates to provide two examples, and if a candidate gives three answers, only the first two should be marked.

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6. Award zero marks for answers which are contradictory.

7. Chemical equations should be balanced except those in reaction schemes for organic synthesis. For energetics, the chemical equations given should include the correct state symbols of the chemical species involved.

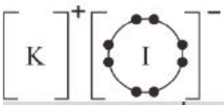
8. In the question paper, questions which assess candidates' communication skills are marked with an asterisk (*). For these questions, the mark for effective communication (1 mark per question) will be awarded if candidates can produce answers which are easily understandable. No marks for effective communication will be awarded if the answers produced by candidates contain a lot of irrelevant materials and/or wrong concepts in chemistry.

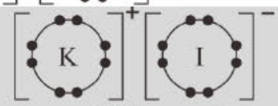
Part I

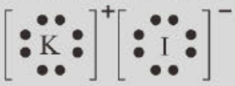
Marks

1. (a) They are isotopes. † — 1

(b) 18 — 1

(c)  — 1

or 

or  (The electron diagram should have brackets)

(d) Hydrogen iodide ionises in water to form mobile ions. / Hydrogen iodide is an electrolyte. — 1

(Not accept: HI is an acid / HI contains free ions. / Incorrect ions are mentioned, e.g. water ionises to form H^+ and OH^-.)

(e) Potassium iodide would have a higher melting point because

- melting of potassium iodide needs a lot of energy to break the strong ionic bonds between K^+ and I^- ions in a giant ionic structure. — 1
- melting of hydrogen iodide needs little energy to break the weak van der Waal's forces between molecules in a simple molecular structure. — 1

(Accept:

- KI has a giant ionic structure while HI has a simple molecular structure. — (1)
- A lot of energy is needed to break the strong ionic bonds between K^+ and I^- ions in KI, while little energy is needed to break the weak van der Waals' forces between HI molecules. — (1)

2. (a)
- oxygen / O_2 — 1
- It relights a glowing splint. — 1

(b) (i) Relative atomic mass of **X** $= \dfrac{2.819}{\left[\frac{(3.028-2.819)}{16} \times 2\right]}$ — 1*

$= 108$ (Accept: 107.50 – 108) — 1

(ii) silver / Ag — 1

(c) Yes.

The oxidation number of **X** decreases from +1 to 0. / The oxidation number of O increases from –2 to 0. (In terms of increase or decrease of oxidation number) — 1

(Accept: Oxidation number of **X** changes from +1 to 0. / Oxidation number of O: $-2 \rightarrow 0$)

Or, $\mathbf{X}^+$ gains electrons from O^{2-}./O^{2-} loses electrons to $\mathbf{X}^+$.(In terms of gain or loss of electrons)

(Accept: Silver ions gain electrons from oxide ions. Not accept: **X** ions / O ions)

Or, $\mathbf{X}_2O$ loses oxygen to form **X**. (In terms of gain or loss of oxygen)

Marks

3\. (a) $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$ / — 1
$NaHCO_3(s) + H^+(aq) \rightarrow Na^+(aq) + CO_2(g) + H_2O(l)$
(State symbols not required)(Ignore incorrect state symbols)

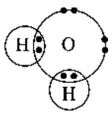
(b) no. of moles of HCl(aq) used = $\underline{0.644 \times 0.0252}$ = 0.01623 — 1*
no. of moles of $NaHCO_3(s)$ in the antacid sample = no. of moles of HCl(aq) used = 0.01623
percentage by mass of $NaHCO_3(s)$ in the antacid sample
= $84 \times 0.01623 \div 1.52 \times 100\%$ = 89.7% (Accept: 89.5 – 89.7%) — 1

(c) (i)
- methyl orange — 1
- From yellow to orange / yellowish orange / orange red — 1
  (Not accept: red)

(ii) pH meter / data-logger connected with a pH sensor — 1

(d) No gas is given out from the reaction between $Mg(OH)_2(s)$ and stomach acid, or while CO_2 / gas is given out from $NaHCO_3(s)$ and leads to uncomfortable feeling in stomach. — 1

4\. (a) (i) — 2



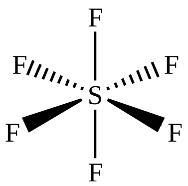
\+ $[H]^+$

1 mark for each diagram
(Accept: H^+; Not accept: $[H^+]$)

(ii) A lone pair of electrons on oxygen atom in H_2O is donated to H^+ to form a dative covalent bond. — 1

(b) No, because boron atom in BF_3 molecule has only 6 outermost shell electrons. — 1
(Not accept: not 8 outermost shell electrons / less than 8 outermost shell electrons)

(c) (i) — 1



(ii) No, because SF_6 molecules is symmetrical, / the polarities of the S－F bonds in SF_6 cancel out. — 1

(d)
- Both molecules of BF_3 and SF_6 are held by weak van der Waals' forces. — 1
- The molecular size of SF_6 is larger than that of BF_3, therefore the van der Waals' forces between SF_6 molecules are stronger than those between BF_3 molecules. — 1
- Stronger hydrogen bonds exist between H_2O molecules. — 1

(Accept: SF_6 molecule has more electrons than BF_3 molecule;
Not accept: Molecules of BF_3 and SF_6 are held by intermolecular forces. / The molecular mass of SF_6 is larger than that of BF_3.)

Marks

5. (a) A cell that cannot be recharged / is non-rechargeable. 1

(b) (i) $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$ 1
(Do not accept: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$)

(ii) Hydrogen is flammable / explosive. / (Concentrated) KOH is corrosive. / 1
Hydrogen / oxygen / gas is difficult to store / transport.
(Do not accept: Need adding hydrogen / oxygen continuously to work. /
The electrode is made of platinum which is expensive. / The fuel cell is bulky.)

(c) (i) $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ 1

(ii) $4Al(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al(OH)_3(s)$ 1
(Do not accept ionic equation.)

(iii) Electrolysis of molten aluminium oxide 1
(Do not accept: Electrolysis of molten ore / salt)
(Accept: Electrolysis of melted / liquid aluminium oxide /
Add $Al_2O_3(s)$ to HCl(aq) to give $Al^{3+}(aq)$ and then add Mg(s) (but not K, Na, Ca).)

Marks

6. (a) Substitution / Monosubstitution † 1
(Do not accept: chlorination of methane / halogenation of methane)

(b) Light / (diffused) sunlight / ultra-violet light / UV/ hν / radical initiator 1
(Do not accept: heat / use a catalyst)

(c) (i) Chlorine free radical (is a species which) has one unshared electron / does not have the (stable) noble gas electronic configuration / does not obey the octet rule / does not have an octet structure. 1
(Do not accept: A chlorine free radical has 7 electrons in its outermost shell. / Chlorine free radical is highly reactive.)

(ii) $Cl\bullet + CH_4 \rightarrow \boxed{\bullet CH_3} + \boxed{HCl}$ 1

$\boxed{\bullet CH_3} + \boxed{Cl\bullet} \rightarrow CH_3Cl$ 1

(Accept: $CH_3\bullet$)
(Do not accept answers expressed using electron diagrams.)

(d) Methane / CH_3Cl undergoes further substitution / polysubstitution to form CH_2Cl_2 / $CHCl_3$ / CCl_4. 1
(Accept:
Cl_2 / $Cl\bullet$ can react with the H atom in CH_3Cl to give other organic products / CH_2Cl_2 / $CHCl_3$ / CCl_4. /
Chloromethane reacts with chlorine to give CH_2Cl_2 / $CHCl_3$ / CCl_4. /
$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$ /
Two methyl radicals react to give CH_3CH_3. / $CH_3\bullet + CH_3\bullet \rightarrow CH_3CH_3$)

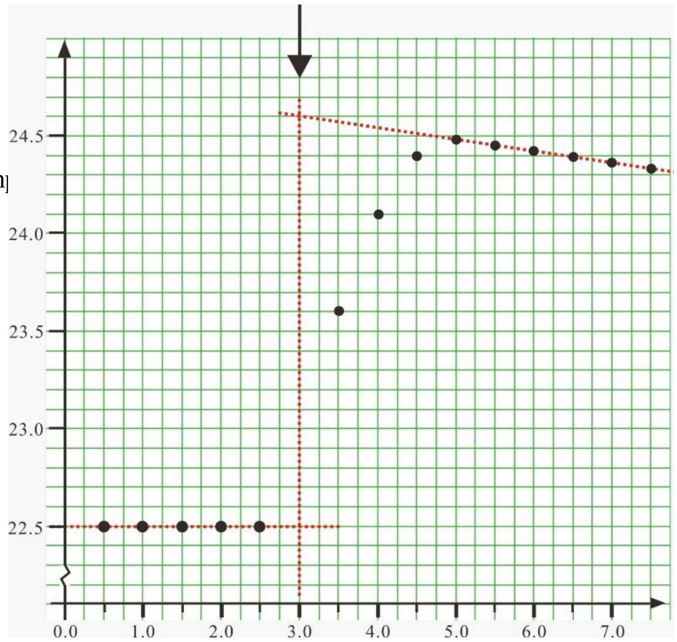
(e) 1

(Do not accept written answer.)

Marks

7. (a) $Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$ / 1
$Ca(OH)_2(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O(l)$
(Accept ionic equation.)
(Do not accept: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$)

(b) (i) 1



(Show the extrapolation line, the vertical line (at the 3rd minute), the horizontal line (at 22.5 °C) and the two intersecting points); or
Show the extrapolation line and mark the coordinate (3, 24.6); or
Show the extrapolation line and 24.6 – 22.5.)

The greatest temperature rise = 2.1 °C 1

(ii) Energy released during the reaction = $\underline{100.0 \times 1.00 \times 4.2} \times 2.1 = 882$ J 1*
Enthalpy change of the reaction = $-882 \div 1000 \underline{\div (0.502 \div 74.1)} = -130$ kJ mol^{-1} 1*
Enthalpy change of neutralisation = $-130 \div 2 = \underline{-65.0}$ kJ mol^{-1} 1
(Accept: –65.0 to –65.33 kJ mol^{-1})

(c) $\frac{1}{2}Ca(OH)_2(s) + HCl(aq) \rightarrow \frac{1}{2}CaCl_2(aq) + H_2O(l)$ $\Delta H_n^o = -58.6$ kJ mol^{-1} 1
$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$ $\Delta H_n^o = -186.0$ kJ mol^{-1}
or
$Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$ $\Delta H^o = -117.2$ kJ mol^{-1}
$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$ $\Delta H_n^o = -186.0$ kJ mol^{-1}

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ $\Delta H^o = y$

$y = -186.0 - (-58.6) \times 2$ 1*
$= -68.8$ kJ mol^{-1} 1
(1 mark for writing out the two thermochemical equations or draw an enthalpy change cycle;
(Correct state symbols must be shown.)
1 mark for the calculation step;
1 mark for the answer with a negative sign and a correct unit)

Marks

8. Chemical knowledge
Similarities (maximum 2 marks):
- Both tin-plating and galvanising involve coating / covering iron with a thin layer of metal (zinc / tin). 1
  (Do not accept 'plating')
- The layer prevents iron from contacting water (and) oxygen. 1

Differences (maximum 3 marks):
- Tin-plated iron will rust / rust faster when tin coating is scratched off but galvanised iron will not rust / rust slower when zinc coating is scratched off. 1
- When the tin coating is scratched off, tin-plated iron will rust because tin will lose electrons less readily than iron / tin is less reactive than iron / tin is lower than iron in electrochemical series (ECS) / tin is a weaker reducing agent than iron. 1
- When the zinc coating is scratched off, galvanised iron will not rust because zinc will lose electrons more readily than iron / zinc is more reactive than iron / zinc is higher than iron in ECS / zinc is a stronger reducing agent than iron / zinc gives sacrificial protection to iron. 1

Communication mark 1
(Chemical knowledge = 0 to 3, communication mark = 0.
Chemical knowledge = 4 to 5, communication mark = 0 or 1.
Incomplete answer or difficult to understand, communication mark = 0.)

Part II

Marks

9. (a) (i) Reaction quotient $Q_c = [PCl_3(g)][Cl_2(g)] / [PCl_5(g)]$ 1

(State symbols not required)(Ignore incorrect state symbols)

$= (0.16 \div 4) \times (0.16 \div 4) \div (0.84 \div 4)$ 1*

$= 7.6 \times 10^{-3}$ mol dm^{-3} (Correct unit is required, not accept M) 1

(Accept: 7.62×10^{-3}, 7.619×10^{-3}, 7.6190×10^{-3})

(1 mark for correct Q_c expression.
1 mark for substituting the correct data into the expression.
1 mark for correct final answer.)

(ii) Concentration of PCl_5 would decrease. As $Q_c < K_c$, the forward reaction rate is greater than the backward reaction rate. 1

(b)
- K_c would increase. 1
- As the forward reaction is endothermic, an increase in temperature favours endothermic reaction / the equilibrium position shifts to the product side. 1

10. (a) $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ 1

(State symbols not required)(Ignore incorrect state symbols)

(b) Manganese/MnO_2 illustrates catalytic property because the rate of formation of gas bubbles (O_2) increases / rate of the reaction increases when $MnO_2(s)$ is present, and MnO_2 remained chemically unchanged at the end of the reaction. 1

(c) theoretical volume of $O_2(g)$ released = $(3.00 \times 0.0100) \div 2 \times 24$ 1*

$= 0.36$ dm^3 or 360 cm^3 1

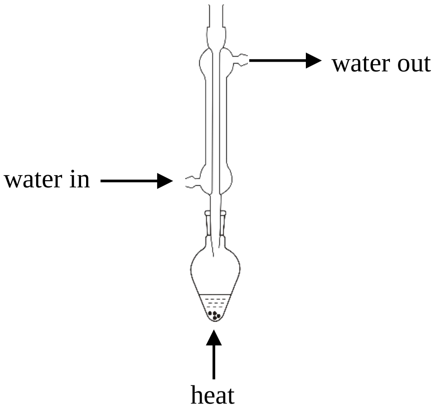
(Correct unit is required)

(d)
- The rate decreases progressively during the reaction / The reaction becomes progressively slower as it takes longer time for foam to reach every 100 cm^3-mark. 1
- Because the concentration of reactant (H_2O_2) decreases in the progress of the reaction. 1

Marks

11. (a) † 2-methylbutan-2-ol / 2-methyl-2-butanol 1

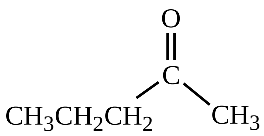
(b) (i) 2



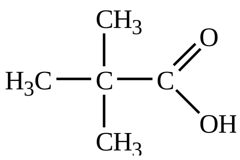
1 mark for correct diagram;
(The diagram should show the flask and the condenser are two pieces of glassware.)
(Not accept: closed system apparatus. E.g. condenser fitted with a stopper)
1 mark for correct labels: correct positions of water in, water out and heat
(Not accept: labelling heat with a triangle or an arrow only)

(ii) The reaction mixture changes from <u>orange to green</u>. 1

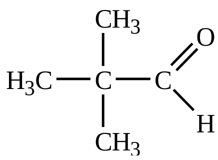
(iii) 1



(c) (i) 1

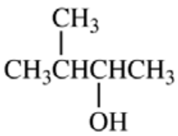


or



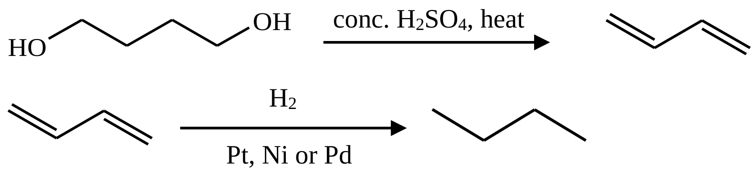
(ii) $LiAlH_4$ (if answered carboxylic acid in part (i)) 1
Or, $LiAlH_4$ / $NaBH_4$ (if answered aldehyde in part (i))
(Not accept: $LiAlH_4$ in acidic/aqueous medium, and $NaBH_4$ in acidic medium.)

(d) 1



Marks

12. 3



(intermediate: 1 mark; reagent: 1 mark for **each step**)
(For 1st step: Accept Al_2O_3 with heat / conc. H_3PO_4 with heat.)
(For 2nd step: If the intermediate is incorrect, but it still has a C=C double bond, and the scheme shows a correct hydrogenation reaction, 1 mark for the reagent if the reagent is correct.)
(Deduct 1 mark, if more than three steps are given.)

13. Chemical knowledge

- Na_2O(s) reacts vigorously with water / dissolve in water to form sodium hydroxide / NaOH(aq) which is (strongly) alkaline / basic. 1
- MgO(s) reacts slowly with water / is slightly soluble in water to form magnesium hydroxide / $Mg(OH)_2$(aq) which is (weakly) alkaline / basic. 1
- Al_2O_3(s) does not react with water / is insoluble / no product is formed. 1
- Cl_2O(g) reacts readily with water / dissolve in water to form hypochlorous acid / HOCl(aq) / HClO(aq) which is (weakly) acidic. 1

(Not accept: just mention Na_2O(s) & MgO(s) are basic oxides / Al_2O_3(s) is amphoteric oxide / Cl_2O(g) is acidic oxide.)

Communication mark 1

(Chemical knowledge = 0 to 2, communication mark = 0
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					Marks
1.	(a)	(i)	(1)	A catalyst is used. / HI/Rh is a catalyst. / Methanol can be made from renewable / biomass. / Atom economy is 100% / (very) high. / CH_3COOH is the only product. / No waste is produced.	1
			(2)	Methanol / CO(g) is toxic. / HI (or CH_3COOH) is corrosive.	1
		(ii)	(1)	It can increase the surface area of the catalyst so as to increase the effectiveness of the catalyst.	1
			(2)	Catalysts can be poisoned by impurities / lead compounds. / The active sites of catalysts are blocked.	1
		(iii)		glass bottle	1
	(b)	(i)		water / H_2O	1
		(ii)	(1)	chlorine / Cl_2	1
			(2)	The concentration of Cl^-(aq) ions is much higher than that of OH^-(aq) ions, Cl^-(aq) ions are preferentially discharged. (A comparative sense)	1
		(iii)	(1)	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ / $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (State symbols not required)(Ignore incorrect state symbols)	1
			(2)	• OH^-(aq) ions are continuously formed in the cathode part. / H^+(aq) ions are discharged while OH^-(aq) ions are remained in the cathode part.	1
				• The ion-permeable membrane only allows Na^+(aq) ions but not Cl^-(aq) ions to pass to the cathode part.	1
		(iv)		sodium hypochlorite / NaOCl / NaClO /sodium chlorate / $NaClO_3$	1

Marks

1. (c) (i) 'Initial rate' is the (instantaneous) rate at the start of a reaction / the rate at time zero. 1

(ii)
- Since $[H^+(aq)]$ is much higher than $[S_2O_3^{2-}(aq)]$, $[H^+(aq)]$ changes only a little / the change in $[H^+(aq)]$ is negligible at the start of the reaction. 1
- $[H^+(aq)]$ is regarded as constant, / then $k[H^+(aq)]^b$ can be regarded as a constant / only $[S_2O_3^{2-}(aq)]$ is a variable. 1

(iii) rate = $k'[S_2O_3^{2-}(aq)]^a$

log (rate) = *log* k' + *a log*($[S_2O_3^{2-}(aq)]$)   (*a* = the slope of the straight line) 1*

Slope = [–1.10 – (–1.50)] ÷ [–1.84 – (–2.24)]   (If not use the dotted lines, 0 mark) 1*

= 1

It is first order with respect to $S_2O_3^{2-}(aq)$. 1

(1 mark for writing correct log equation,
1 mark for substituting correct data,
1 mark for giving correct answer)
(Accept : other methods of calculations)

(iv)

$$log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.3R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$log\,(1.9) = \frac{E_a}{2.3 \times 8.31}\left(\frac{1}{298} - \frac{1}{308}\right)$$ 1*

Ea = (+)48.90 kJ mol^{-1} 1

(Accept: 48.805 – 49.004;
Accept : no unit ;
Not accept: unit in kJ)

Marks

2. (a) (i) (1) Particles of materials with sizes between 1–100 nm / less than 100 nm — 1

(2) making stained glass / colour windows — 1

(ii) (1) Diagram **C** — 1

(2) nematic phase — 1

(iii) Atom economy = $\frac{32.0}{2\times40.0+71.0+2\times17.0}\times 100\% = 17.3\%$ (Accept: 17%) — 1

(b) (i) face-centred cubic / cubic close-packed † — 1

(ii) No. of aluminium atoms in the unit cell = 8 × ⅛ + 6 × ½ = 4 (need to show the step) — 1

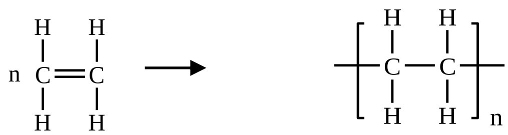
(iii) Density of aluminium = $27.0 \times 4 \div (6.02 \times 10^{23}) \div (4.05 \times 10^{-8})^3$ — 1*
= 2.70 g cm^{-3} — 1
(Accept: 2.7 g dm^{-3}; no need to show the unit)

(iv) (1)
- In the duralumin sample, atoms of different sizes added (Cu/Mg/Mn atoms) distort the regular packing of atoms in pure aluminium / become irregular packing / become not closely packed. — 1
- This reduces the (strength of) metallic bonding and leads to a lower melting point. — 1

(2) Agree.
This kind of duralumin has a greater tensile strength /stronger than pure aluminium. — 1
(Accept: greater hardness / rigidity / toughness)
(Do not accept: lower density / higher corrosion resistance)

Or, Not agree.
This kind of duralumin has a lower melting point. — (1)

(c) (i) — 1



(ii) addition (polymerisation) † — 1

(iii) (1)
- HDPE has a linear structure / linear polymer chains / with less branches, the chains are packed more closely. — 1
- There are stronger van der Waals' forces between polymer chains in HDPE than in LDPE. — 1

(2) blow moulding — 1

(iv) (1) thermosetting / low thermal conductivities (good heat insulation) — 1

(2) Because there are strong cross-links / covalent bonds between polymer chains. — 1

(3) resistant to corrosion / flexible / bent easily — 1
(Do not accept thermal properties related answers)

Marks

3. (a) (i)
- Pass the two gases to $K_2Cr_2O_7/H^+(aq)$ separately. 1
- $SO_2(g)$ can turn $K_2Cr_2O_7/H^+(aq)$ from orange to green, while there is no observable change for $CO_2(g)$. 1

(A comparative sense)
(If H^+ is not present in $K_2Cr_2O_7$, 0 mark for both reagent and observation.)

Or, Using $KMnO_4/H^+(aq)$,
$SO_2(g)$ can turn $KMnO_4/H^+(aq)$ from purple to colourless / (very) pale pink, while there is no observable change for $CO_2(g)$.
(If H^+ is not present in $KMnO_4$, 0 mark for both reagent and observation.)

Or, Using $Br_2(aq)$ or Br_2(in organic solvent),
$SO_2(g)$ can turn $Br_2(aq)$ from reddish brown to colourless / $SO_2(g)$ can turn Br_2(in organic solvent) from orange/brown to colourless, while there is no observable change for $CO_2(g)$.
(Not accept: red or yellow for colour of $Br_2(aq)$ or Br_2(in organic solvent))
(Not accept: $Br_2(l)/Br_2(g)$ as the reagent, BUT can give mark to correct observation)

(Accept: other possible chemical tests)

(ii) The mass spectra of CH_3CH_2CHO and CH_3COCH_3 are recorded respectively.
- In the mass spectrum of CH_3CH_2CHO, a significant peak appears at m/z = 29 / corresponding to CHO^+ / $CH_3CH_2^+$, while this peak does not appear in the mass spectrum of CH_3COCH_3. 1
- In the mass spectrum of CH_3CH_2CHO, a significant peak appears at m/z = 57 / corresponding to $CH_3CH_2CO^+$, while this peak does not appear in the mass spectrum of CH_3COCH_3. 1

Or, In the mass spectrum of CH_3COCH_3, a significant peak appears at m/z = 43 / corresponding to CH_3CO^+, while this peak does not appear in the mass spectrum of CH_3CH_2CHO. (1)

(A comparative sense)

(iii) (Anhydrous) sodium sulphate / Na_2SO_4 1

(b) (i) The maximum mass of **Y** can dissolve in 50 cm^3 water at 80ºC = 3.04 × 50/100= 1.52 g. 1
As the mass of **Y** in the solid sample should be less than 1.4 g, therefore all **Y** should have dissolved.
(or 3.04 g to compare with 2.8 g)

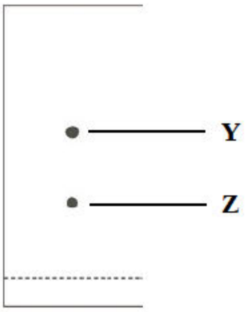
(ii) To remove the water-insoluble activated charcoal. 1

(iii) crystallisation † 1

(iv) Some **Y** do not crystallise / are left on the filter paper / are washed away. 1
(Not accept: 'Loss during the steps', need to mention the specific step.)

Marks

3. (b) (v) (1) 2



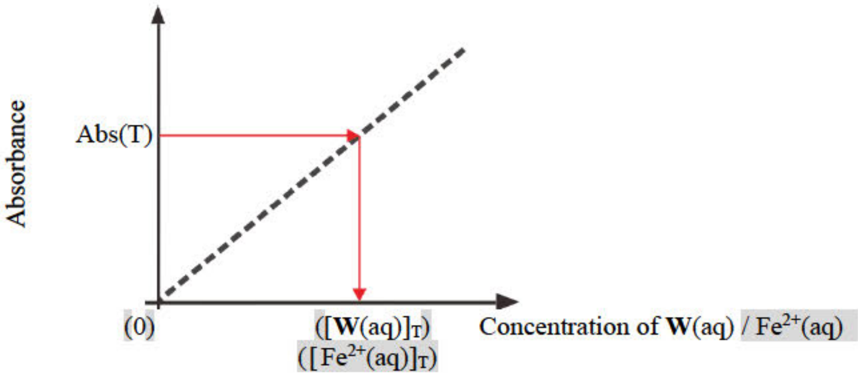
(1 mark for sketching correct chromatogram (2 points and 1 line for starting position / 3 points with one point representing the starting position);
1 mark for correct labels (**Y** and **Z**; **Y** is higher than **Z**))

(2) **Y**,
because **Y** has a larger R_f value / **Y** moves faster / **Y** takes a shorter time to reach the bottom of the column. 1

(c) (i) (1)
- pale yellow colour: Fe^{3+}(aq) ions 1
- pale pink colour: MnO_4^-(aq) ions 1

(2) concentration of Fe^{2+}(aq) ions in solution **S** = 0.0041 × 32.35 ÷ 25 × 5 1*
= 0.0265 M 1
(Accept: 0.027, 0.02653)

(ii) (1) 3



(1 mark for straight line of calibration curve;
1 mark for labels of axes;
1 mark for two lines to find $[\mathbf{W}(aq)]_T$)

(2) Concentration of Fe^{2+}(aq) ion in solution **S**
= Concentration of **W**(aq) in solution **T** × 100 1
= ($[\mathbf{W}(aq)]_T$ × 100) or ($[Fe^{2+}(aq)]_T$ × 100)