1 **(a** same number of protons [1]
same number of electrons [1]
different number of neutrons [1]

(b) ^{235}U / ^{239}Pu [1]
NOTE: need symbol or name and nucleon number

(ii) treating cancer / chemotherapy / radiographs / tracer studies / x–ray (scans) / sterilise surgical instruments / diagnose or treat thyroid disorders / radiotherapy [1]

paper thickness / steel thickness / radiographs / welds / tracing / fill levels in packages / food irradiation / smoke detectors [1]
ACCEPT: any other uses

(iii) $Zr + 2H_2O \rightarrow ZrO_2 + 2H_2$ [2]
not balanced = (1) only

(iv) hydrogen explodes / fire (risk) [1]

(c)

if the oxide is	predicted result with hydrochloric acid	predicted result with aqueous aqueous sodium hydroxide
acidic		R
neutral		NR
basic		NR
amphoteric		R

(1) per l [4]

[Total: 13]

2 **(a) (i)** $S + O_2 \rightarrow SO_2$
or sulfur burnt / roasted / heated in air to form sulfur dioxide [1]

$2SO_2 + O_2 \rightleftharpoons 2SO_3$ [2]
unbalanced = (1) only

(catalyst) vanadium(V) oxide / vanadium pentoxide [1]
(temperature) 440 to 460 °C [1
(dissolve) sulfur trioxide in sulfuric acid (to form oleum) [1]
ignore comments about pressure

(ii) add oleum to water [1]

(b) $Ba(C_6H_{13}SO_3)_2$ / $(C_6H_{13}SO_3)_2Ba$ [

(c) → magnesium hexanesulfonate + hydrogen [1]

(ii) → calcium hexanesulfonate + water [1]

(iii) $2C_6H_{13}SO_3H + Na_2CO_3 \rightarrow 2C_6H_{13}SO_3Na + CO_2 + H_2O$

$C_6H_{13}SO_3Na$ = (1) [1]
remaining species correct and equation balanced = (1) [1]

(d) measure pH / add universal indicator [1]
both acids have a low value / pH 0–2 / same colour / red [1]
or
measure rate with named reactive metal, Mg, Zn (1)
both fast reactions (1)
or
measure rate using piece of insoluble carbonate, $CaCO_3$ (1)
both fast reactions (1)
NOTE: must be insoluble for first mark
or
measure electrical conductivity (1)
both good conductors (1)

(ii) to have same concentration of H^+ / one acid is H_2SO_4, the other is $C_6H_{13}SO_3H$ / sulfuric acid is dibasic, hexanesulfonic is monobasic [1]

(iii) a strong acid is completely ionised, [1]
a weak acid is partially ionised [1]

[Total: 17]

3 **(a) (i)** kills microbes / bacteria / fungi / micro-organisms etc. [1]

(ii) as a bleach [1]

(iii) burn / heat sulfur in air / oxygen [1]

(b) oxygen [1]
vanadium oxide / vanadium(V) oxide / vanadium pentoxide [1]
not an incorrect oxidation state
400 °C to 450 °C [1]
water [1]

(c) proton donor [1]

(ii) measure pH / use pH paper [1]
sulfuric acid has the lower pH [1]
accept colours / appropriate numerical values

OR

measure electrical conductivity [1]
sulfuric acid is the better conductor [1]

OR

add magnesium / named fairly reactive metal [1]
ethanedioic acid gives the slower reaction [1]
NOTE result must refer to rate not amount

OR

add a carbonate [1]
ethanedioic acid gives the slower reaction [1]
NOTE result must refer to rate not amount

(d) (i) how many moles of H_2SO_4 were added = 0.02 × 0.3 = 0.006 [1]

(ii) how many moles of NaOH were used = 0.04 × 0.2 = 0.008 [1]

(iii) sulfuric acid [1]
only mark ecf if in accord with 1:2 ratio and with values from **(i)** and **(ii)**.
reason 0.006 > 0.008/2 [1]
for ecf mark candidate must use 1:2 ratio in answer

(iv) less than 7 [1]

[Total: 15]

4 **(a** (total endothermic change = 436 + 242 = +)678 kJ [1]
(total exothermic change = 2 × 431 = –)862 kJ [1]
accept correct sign/supplied/absorbed for endo etc.
accept correct sign/evolved/produced for exo etc.
change for reaction = –184 kJ [1]

not necessary to calculate –184, just show that exo change > than endo
ecf allowed provided negative
–184 kJ scores all 3 mark

(b) because it accepts a proton [2]
accepts hydrogen ion **or** H^+ **ONLY** [1]
proton and H^+ [2]

(ii) hydrogen chloride is a strong acid [1]
hydrogen fluoride is a weak acid [1]
weaker **or** stronger correctly applied for [2]

(iii) hydrogen chloride (aqueous) would have lower pH [1]
OR hydrogen fluoride (aqueous) would have higher pH
If values suggested, not over 7

[Total: 8]