1		
	(a) rotation (or wobble) of the axis of spin	(1)
-	about the direction of the external magnetic field	(1)
	(b) hydrogen	(1)
	any two from:	
	abundant in the body	(1)
	odd number of protons (allow odd number of nucleons) possess the property of spin	(1) (1)
	possess magnetic moment (act like tiny magnets)	(1)
		443
	(c) the frequency of precession (of the targeted nuclei) found in the radio frequency part of the e/m spectrum	(1) (1)
		
	(d) different types of tissue have different relaxation times	(1)
2	Any 7 e.g.	
	nuclei /atoms, (with unequal nos. of neutrons and protons) spin	(B1)
	act like tiny magnets	(B1)
	align in an external magnetic field they precess / wobble	(B1) (B1)
	RF radiation pulse is applied	(B1)
	resonance occurs / nuclei flip	(B1)
	RF emitted by nuclei and detected	(B1)
	the time taken for the nuclei to return to their equilibrium state (is	•
	 / time taken to return to equilibrium state is called the relaxation to hydrogen atom is (most commonly) used 	ime (B1) (B1)
	different tissues have different hydrogen content and so can be d	
		
		(B1)
	any 2 e.g.	
	it is <u>non-ionisina</u>	(B1)
	it is <u>non-ionising</u> differentiates well between tissues (of similar density)	(B1) (B1)
	it is <u>non-ionisina</u>	(B1)
3	it is non-ionising differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given	(B1) (B1)
3	it is non-ionising differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin	(B1) (B1) (B1)
3	it is non-ionising differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets	(B1) (B1) (B1) (B1)
3	it is non-ionising differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field	(B1) (B1) (B1) (B1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble refradiation is sent in	(B1) (B1) (B1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble fradiation is sent in at resonant frequency of precession / at Larmor frequency	(B1) (B1) (B1) (B1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted	(B1) (B1) (B1) (B1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble fradiation is sent in at resonant frequency of precession / at Larmor frequency	(B1) (B1) (B1) (B1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms	(B1) (B1) (B1) (B1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms One detail mark for eg	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf_radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms One detail mark for eg hydrogen is most commonly used / different relaxation times in fat and water / value for size of magnetic field > 1 T / gradient in magnetic field needed	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms One detail mark for eg hydrogen is most commonly used / different relaxation times in fat and water / value for size of magnetic field > 1 T / gradient in magnetic field needed Agreement with student's comment	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms One detail mark for eg hydrogen is most commonly used / different relaxation times in fat and water / value for size of magnetic field > 1 T / gradient in magnetic field needed Agreement with student's comment (no because) radio frequency radiation is sent into the patient	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1) (1)
3	differentiates well between tissues (of similar density) higher resolution allow response if corresponding disadvantages given any relevant response to a maximum of 8 e.g. atoms with unequal numbers of protons and neutrons spin act as tiny magnets align in external magnetic field and precess / wobble rf radiation is sent in at resonant frequency of precession / at Larmor frequency r.f. radiation is emitted (as atoms return to the unexcited state) relaxation times are measured / relaxation times identify different atoms One detail mark for eg hydrogen is most commonly used / different relaxation times in fat and water / value for size of magnetic field > 1 T / gradient in magnetic field needed Agreement with student's comment	(B1) (B1) (B1) (B1) (1) (1) (1) (1) (1) (1) (1)

4 one each to a max. 10 e.g. Atoms with uneven number of protons and neutrons	
spin, Ref. to hydrogen as being commonly used So act like tiny magnets Align in an external magnetic field / parallel and anti- parallel Precess / wobble Rf sent in (at frequency of precession/ Larmour frequency) Resonance occurs / they flip Rf turned off and amplitude of precession dies down Atoms emit rf while returning to equilibrium state Rf detected by (induced emf in) pick up coils Precession frequency is proportional to B-field Magnetic field gradient means precessions frequency depends upon position Hence 3-D scan possible Time to return to equilibrium state called relaxation time 2 relaxation times Each tissue has a different relaxation time so tissues may be identified to max. of 4 example (1) reason (1) e.g. brain scan Skull absorbs ct signal or X-rays / pregnant subject might be exposed MRI signal not affected by more dense material / bone has proton density similar to / less than other tissues so similar MRI strength Good at soft tissue differentiation Not good where metal implants / pacemakers etc Not good for eye / due to local heating	4

	Question	Expected Answers	Marks
5	Question	any 7 e.g. atoms with unequal nos. of neutrons and protons, spin act like tiny magnets strong external magnetic field applied atoms align in this magnetic field they precess / wobble when a RF radiation (pulse) is applied resonance occurs / atoms flip RF is emitted as atoms return to their equilibrium state the time taken for the atoms to return to their equilibrium state is measured allow one detail mark from the following (up to max 7): two relaxation times hydrogen atoms usually used magnetic field gradient across the length and width of the body	1 1 1 1 1 1 1 1 1
		any 2 e.g. it is non-ionising differentiates well between tissues of similar density MRI not affected by the bone of the skull allow response if corresponding disadvantages given	1 1 1