/kg SAR ⇐⇒ 1. $\mu W/cm^2$

e/m wave where E (electric field) in V/m
H (mag. field) in A/m
at any point are proportional to each other
$\therefore$ $E/H = 120\pi = 377\ \Omega$ (free space impedence)

Energy Flux (S) impacts onto an object and is Exposure.

(electric) $S = E^2/377$ W/m^2
(mag) $S = 377H^2$ W/m^2

Magnetic Flux Density (B) = μH (Tesla)
(μ = permeability $\approx \mu_0 = 1.257 \times 10^{-6}$ H/m

Exposure is frequently expressed in $\mu W/cm^2$

As e/m field propagates away from radiating source Energy Flux decreases thus:

$$S = P/4\pi r^2$$

P = radiated power r = dist. from antenna.

For isotropic antenna (equal in all directions) = simple calc. : problems arise from ; directional beam, side lobes increased power :
(gain of x 6 + can be achieved)

The Energy Flux may be reflected, scattered & absorbed by an object. Most efficient absorption = λ is twice the size of the object.
i.e. larger objects absorb. longer λ's at lower f's
smaller .... smaller λ's " higher f's

A 1.8m person has peak absorption ≈ 70 MHz
A monkey at 300 MHz
Adult head at 915 MHz
Mouse at 2450 MHz.

Absorbed energy is normally expressed as the S.A.R. Specific Absorption Rate which in terms of the Electric Field is :

$$SAR = \frac{\sigma E^2}{2\rho} \quad [W/kg]$$

ρ = density of tissue (kg/m³) : σ = elec. conductivity of tissue (Siemens/m²) (S/m²)

At Low Frequencies σ = 0.1 -> 0.35 for heart
0.1 -> 0.3 for nerve
0.2 for brain

At MicroWave σ = 0.05 for bone
0.95 for muscle
0.77 for organs

ρ of most tissue ≈ 1000 kg/m³ because of the presence of water :
[N.B. lung is ≈ 100 kg/m³ because of air]

Worked Example:

Calc. the S.A.R. of MW on the brain where:

$\sigma = 0.77 \quad S/m^2$

$E = 100\ V/m$ (Typical for 1.8 GHz)

(E = electric field strength)

$\rho = 1000\ kg/m^3$ (watery brain)

$$S.A.R. = \frac{\sigma E^2}{2\rho}$$

(1) $$\Rightarrow \frac{(0.77)(100^2)}{2(1000)} = \underline{\underline{3.85\ W/kg}}$$

Whilst in terms of heating:

$$SAR = \frac{C\,DT}{dt}$$

C = Specific heat of tissue $J/kg\ ^\circ C$

$\frac{DT}{dt}$ = rate of increase of temp.

Combining Energy Flux $S = E^2/377 \quad W/m^2$

and S.A.R. $\frac{\sigma E^2}{2\rho}$

we have $S = 2\rho / 3.77\sigma \quad \mu W/cm^2$

T.

i.e. for ① we have

$$\frac{2p}{3.77\sigma} \Rightarrow \frac{2.000}{(3.77)(0.77)}$$

$$= \underline{\underline{688.966\ \mu W/cm^2}}$$

∴ 3.85 W/kg ≈ 688 μW/cm²
∴ 1.0 W/kg ≈ 178 μW/cm²

For f 100 KHz → 300 GHz
Basic Restrictions (NRPB.)

100 KHz - 10 GHz	(whole body in any 15 min period)	0.4 W/kg
	for 10g of head or foetus in 6 min	10 W/kg
	100g in limbs in 6 min	20 W/kg

Exposure in Specific Situations.

		W/kg
50 cm	from car antenna	0·05
550 m	from air control radar	0·04
30 cm	from microwave oven (with leak)	0·04
12 m	from tracking radar (in beam)	6·1

Definitions.

i 1 Hertz = one cycle per sec.

ii ELF = Extremely low frequency (1 → 300 Hz ≈ 50/60 Hz UK/USA)

iii RF = radiofrequency

iv Below 30 MHz electric and magnetic fields are usually measured in V/m and A/m.

v Magnetic flux density - Tesla i.e. 30 μT

vi Above 30 MHz electric and magnetic fields are usually measured in W/m^2 or $\mu W/cm^2$

e.g. 1 A/m = 1·25 μT

0·1 mV/cm = 100 V/m

RF ≈ 100 kHz → 300 MHz

micro wave MW ≈ 300 MHz → 30 GHz (radar 3–20 GHz)

$1\ W/m^2 = 100\ \mu W/cm^2$ (μ = micro)

$10\ W/m^2 = 1000\ \mu W/cm^2$

HOLDING A MOBILE TO YOUR HEAD

Power Varies $\approx 2W/m^2$

Power on Side of head, of area $324 \times 10^{-4}\ m^2$

$= 2 \times (324 \times 10^{-4}\ m^2) = 0.0648\ W$ or J/s

Energy of each photon $= h\nu \Rightarrow h\,c/\lambda$ where $h = 6.6 \times 10^{-34}$

$c = 3.0 \times 10^8$ $\lambda = 1.0 \times 10^{-4}\ m$ $\therefore$ energy $= 1.98 \times 10^{-21}\ J$

Actual number of photons incident on head $\Rightarrow$

total energy $\div$ photon energy $\Rightarrow 0.0648 / 1.98 \times 10^{-21}$

$= 3.2 \times 10^{19}\ s^{-1}$

Energy to release e^- from Hydrogen bond in body is

$0.85\ eV \Rightarrow 0.85(1.6 \times 10^{-19}\ J) = 1.36 \times 10^{-19}\ J$

$\therefore$ energy to release each e^- $\div$ energy per photon

$1.36 \times 10^{-19} / 1.98 \times 10^{-21} = 68.68 \Rightarrow$

≈ 68 photons will release each e^-.

$\therefore$ total number of photons s^{-1} incident on head $\div$ number to release each $e^- = 3.2 \times 10^{19} / 68.68$

$= 4.65 \times 10^{17}$

$\therefore$ Electrical Current Generated $(4.65 \times 10^{17})(1.6 \times 10^{-19})$

$= 0.0736$ Amps.

(may require constructive interference at one stage which is easily optained)

Electrical Conductivity of Brain $\approx$ 1 to 9.1 $S\,m^{-1}$

but $S m^{-1} \Rightarrow I/V \Rightarrow V = I/S m^{-1}$

$\therefore$ electrical potential induced in brain $\because$

$$0.0736/1 \quad \text{or} \quad 0.0736/9.1$$

$$= 0.0736\ V \quad \text{or} \quad 8.0 \times 10^{-3}\ V$$

Potentials for K^+ Na^+ Cl^- in our bodies

	inside	(concentrations)	outside
K^+	150		2.5
Na^+	15		145
Cl^-	9		101

using : $\frac{RT}{ZF} \times 2.303 \log_{10} Co/Ci$ V

where : R (gas) 8.314 $JK^{-1}\,mol^{-1}$
T (temp.) K^{-1}
Z (valency)
F (Con.) Faraday 96500 C mol^{-1}
Co. Concentration outside cell
Ci. Concentration inside cell

$\therefore$ for $K^+ \Rightarrow \dfrac{(8\cdot314)(291)}{(+1)\ (96500)}\ 2\cdot303\ \log_{10} \dfrac{2\cdot5}{150}$

$= 0\cdot012\ V$

for $Na^+ = 0\cdot056 V$: $Cl^- = -0\cdot06 V$

Normal Cell Potential	Induced Potential
K^+ 0·012 V	0·0736 to 0·008 V
Na^+ 0·056 V	depending on electrical
Cl^- −0·06 V	conductivity of brain

Clearly the electrical properties of the brain are compromised by a change in potential due to an induced current.

interestingly, if we look at collision momentum at the photon, say, on the skin with an atomic particle say proton :

we have : $m_1 v_1 = m_2 V_2$

$\Rightarrow (3\cdot99\times10^{-34})(3\cdot0\times10^{8}) = (1\cdot672\times10^{-27}) \times V_2$ (pro

$\Rightarrow V_2 = 71\cdot59\ m\ s^{-1}$

where as normal velocities for such particles in the body is $\approx 30\ m\ s^{-1}$.

In other words, there is enough momentum from these microwaves to change the speed of particles within the body!

Such claims have been made from pulsing microwaves, where the natural pulse rhythm of the brain :

1 → 4	Delta	(Sleep)
5 → 7	Theta	(Susceptibility to learn / tranquility)
8 → 12	Alpha	(relaxed / alert)
13 ↑	Beta	(Consciousness / decisions)

may be affected by the electrical variation and / or atomic collision (change in momentum) of the natural frequency of the brain .

B. TROWER 19 · 2 · 2005

The (dB) or (dBm)

This is a ratio and should not be confused with power output. It is usually the ratio of two different voltages or powers: e.g. the comparison (ratio) between a directional or non directional aerial set-up.

$$dB = 10 \log_{10} \left(\frac{P_2}{P_1} \right)$$

Suppose $P_1 = 50$ mW and $P_2 = 500$ mW then the dB =

$$10 \log_{10} \frac{500}{50} = 10 \text{ dB}$$

if $P_1 = 50$ mW and $P_2 = 1000$ mW then dB = 13

For some transmitter 'set-up's' we have:

dBm	Watts
45	30
40	10
35	3
30	1

Another may be:

7/

(dBm)	Watts
46	40
44	25
42	16
40	10
38	6.3
36	4
34	2.5
32	1.6
30	1
28	0.6

The actual Government definition is:
(dB) A measure of the increase or decrease in Power 'P' at two points expressed in Logarithmic form.

$$\text{Gain} = 10\log_{10} P_2 / P_1$$

With all of this, forget the (dB) and look at the actual dose incident on the sleeping person.

A good measurement (dose) to look at is the micro Watt for each centi-metre\2 ~ cm\2 is one square centi-metre.

i.e. Look at $\mu W / cm^2$ $\left[\mu = \frac{1}{1000\,000} \right]$

In your report where dB(m) is used :
i.e. Effective Power (dBm) = E-field (dBμV/m) − 107
where E = electric
and Effective Field = 20 Log (? base) [vertical μV/m]^2 + [μV/m]^2

really boils down to a ratio of a ratio !

dBm is not an internationally recognised unit and cannot give a true representation of actual power output.
It is at the very least ~ confusing. Probably deliberatly so and at worst, impossible to follow.

In the end it is meaningless as a representation of power output.
The question is ~ what is wrong with giving the ordinary power output in recognised S.I. units ?
(Please see table)

The (m) in dBm is unclear. It could be metre or milli !

I think it is to confusing to follow. Possibly the only person who may make head or tail of this would be a University Lecturer in Electrical Engineering. But I suspect you may get the same reply.

Summary.

The bottom line here is:

Effective Power (dBm) = Effective field in dBμV/m
i.e. a ratio = a ratio

Hence this is a ratio not a power output.

If you can find the actual Power of the transmitters (in Watts) just divide it by (d^2) where d = distance in metres.

i.e. if the transmitter is 20W and you are 10m away your dose is:

$$\frac{20}{10^2} = \frac{20}{100} = 0.2\ W/m^2$$

$$= 20\mu W/cm^2$$

(way above most international safety levels)

Please accept that I am not an electrical engineer and you may achieve a better result consulting one.

If you have anybody else out to read the power ~ best to ask the units first.

Power (W/m²)	Power (μW/cm²)	E (V/m)	M (A/m)	Flux φ (μT)
0·1	10	6·14	0·016	0·020
1·0	100	19·42	0·052	0·065
10·0	1000	61·4	0·163	0·204
50·0	5000	137·3	0·364	0·455
100·0	10000	194·16	0·515	0·644

At 1m Tetra = 13·4 V/m
2m " " = 6·7 V/m

* Cherry (0·01 μW/cm²) max limit

SAR of 1 W/kg = 178 μW/cm²

* Prof. N. Cherry's maximum Level recommended to four Governments.