Answer to exam in Material och tillverkningsteknik (2008-08-19)

1. Atomic structure and interatomic bonding (4 P)

a) P^{5+}: $1s^2 2s^2 2p^6$ P^{3-}: $1s^2 2s^2 2p^6 3s^2 3p^6$
Ni^{2+}: $1s^2 2s^2 2p^6 3s23p^6 3d^8$ Cu^{1+}: $1s^2 2s^2 2p^6 3s23p^8 3d^{10}$

b) (i) See Callister!
(ii) K^+ has the electron configuration of Ar, and I^- has the configuration of Xe.

c) (i) For solid xenon, the bonding is van der Waals since xenon is an inert gas.
(ii) For CaF2, the bonding is predominantly ionic (but with some slight covalent character) on the basis of the relative positions of Ca and F in the periodic table.
(iii) For bronze (Cu-Sn), the bonding is metallic since it is a metal alloy.
(iv) For CdTe, the bonding is predominantly covalent (with some slight ionic character) on the basis of the relative positions of Cd and Te in the periodic table.
(v) For rubber, the bonding is covalent with some van der Waals. (Rubber is composed primarily of carbon and hydrogen atoms.)
(vi) Tungsten is a metal, hence the bonding is metallic.

2. Phase diagrams (6 P)

a) Compare Callister!
$L \rightarrow \alpha$ (and respectively for β, for both pure elements)
$L \rightarrow \alpha + L \rightarrow \alpha + \beta$ (and respectively for β)
$L \rightarrow \alpha + \beta$ (without passing the 2-phase field of $L+\alpha$ or $L+\beta$) at the eutectic composition

b)

(i) $W_F = (6.7 - 3)/(6.7 - 0.022) = 0.554 \rightarrow 55.4\%$
Composition: W_F: Fe - 0.022 wt.%C
$W_{Fe3C} = (3\text{-}0.022)/(6.7\text{-}0.022) = 0.446 \rightarrow 44.6\%$
Composition: W_{Fe3C}: Fe- 6.7 wt.%C

(ii) $W_{Fe3C} = (3\text{-}0.77)/(6.7 - 0.77) = 0.376 \rightarrow 37.6\%$

c) Compare Callister (microstructure consists of austenite grains and a lamellar structure of Fe_3C and γ)!

3. Mechanical properties (4 P)

a) In the plastic regime the bonds are stretched during tensile testing but when the force/stress is released, the sample is returning to its initial shape. In the elastic regime, stress/force is so large that bonds are broken and new bonds are established (deformation occurs!) and the sample would not return to its initial shape when the force/stress is released.

b) A slip system is the combination of a crystallographic plane (glide plane) and a crystallographic direction (glide direction) in which dislocation movement occurs (deformation).
c) A brittle material will break when deformed/exposed to a sudden blow (example when you drop ceramic mug). A ductile material can be deformed to a certain extend (ductility: % elongation) before it will break/fail.
The brittle-ductile transition can be measured with help of the Charpy test (pendulum). The test is performed with samples which are at different temperatures and the amount of absorbed energy is determined. In that way the transition temperature can be found.

4. Electrical properties (3 P)

a) Compare Callister!

b) Electrical conductivity id decreasing for metals upon increase in temperature. This is due to the vibration of the atoms which results in increased scattering of the travelling free electron. The temperature effect is one of the influences being described in Matthiesen's rule.

For silicon (intrinsic semiconductor), there is an increase in conductivity with temperature. At low temperatures the energy is not sufficient to excite electrons over the band gap into the conduction band; hence conductivity is close to zero. Increasing temperature, more and more free electrons are available (due to higher energy, they can overcome the band gap) and conductivity is increasing. There is also a negative effect and thermal vibrations occur but the positive effects on conductivity are more dominant; also mobility is increasing with temperature.

5. Plastic behaviour of metals (7 P)

a) One horizontal straight line and one straight line with a positive angel (~10-40º).

b) Warm and cold forming methods.

c) At and above, forming of new undeformed crystal grains.
(New equiaxed and strain-free grains are developed and replacing the older grains.)

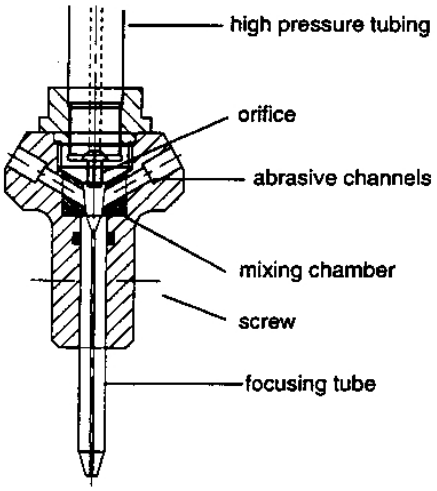
d) Warm - no work hardening, Cold – clear developed work hardening behaviour.

e) Warm – n = 0, Cold – n = 0,1 – 0,6.

6. Unconventional machining methods: Abrasive waterjet machining (3 P)

At the end of a high pressure water tubing a small orifice, with a diameter generally in the range of 0.1-0.6 mm, is installed. This nozzle is usually made of sapphire or diamond. Through this orifice the high-pressure water is expelled and a pure waterjet is formed. The waterjet leads then into the mixing chamber. Through the interaction of the pure waterjet and the surrounding air a vacuum pressure is created in the mixing chamber causing airflow from

outside through the abrasive channels to the mixing chamber. In the mixing process of the waterjet with air and abrasives the jet loses its coherency, therefore a focusing tube is installed below the mixing chamber to form a coherent abrasive waterjet. The resulting diameter of the abrasive waterjet is nearly equal to the focusing tube diameter. The focusing tube is exposed to extremely severe abrasive conditions, therefore it is made of a very wear resistant material.



Process parameters: Water pressure, abrasive mass flow rate. Orifice and nozzle diameters

7. Metal Cutting –turning (4 P)

1. Räkna ut nominell spåntjocklek och läs av kc:
hd=f*sin kappa
hd 0,247487373
kc ur tabell 2500

2. Räkna ut max skärdjup:
Fc= kc*ap*f
ap 3,085714286
Alltså: Väljer skärdjup 3mm

Diameter	Skärdjup	Matning	Skärhastighet	Varvtal (obearb dia)	Ingreppslängd	Ingreppstid
100						
94	3	0,35	200	637	300	1,35
88	3	0,35	200	677	300	1,27
86	1	0,35	200	723	300	1,18
					Summa	3,80

Svar: Totala ingreppstiden är ca 3,8 minuter

8. Metal Cutting – theory (4 P)

Solution see page 352-352 in the book

9. The viscoelastic properties of polymeric materials (5 P)

a) Tidsberoende mekaniska egenskaper beroende av tid (1 P). Temperatur och belastning inverkar på deformationshastigheten (2 P).

b) Krypning innebär konstant last och tidsberoende deformation (1 P), relaxation innebär konstant deformation och tidberoende spänning (1 P)

10. Glas transition and melting point of polymers (5 P)

a) Vid glasomvandlingstemperaturen övergår amorfa delar från fast fysikaliskt glas till vätska, medan kristaller smälter och övergår i vätska vid smältpunkten. Båda processerna är reversibla. (2 P)

b) Utvecklingen av den specifika volymen beskrivs i figur 10.14 s 487 (1 P)

c) Sfäruliter, bestående av kristall-lameller som växer radiellt, fringed mi-celles and single crystals. (1 p) + figurer (1 P)

11. Plastics materials (5 p)

a) PE, PP, PVC och PS (1 P)
b)
c) Se boken, benämningar (1 P), typiska egenskaper för polymererna där argumentation möjlig (2 P)
d)
e) Se boken, mest förpackningar, rör, folier, lister etc (1 P)